Marine Science Affairs

—A Year of Plans and Progress

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THE SECOND REPORT OF THE PRESIDENT TO THE CONGRESS ON MARINE RESOURCES AND ENGINEERING DEVELOPMENT

MARCH 1968

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Marine Science Affairs

—*A Year of Plans and Progress*

THE SECOND REPORT OF THE PRESIDENT TO THE CONGRESS ON MARINE RESOURCES AND ENGINEERING DEVELOPMENT

FEBRUARY 1968

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WASHINGTON, D.C.,
March 1968.

TO THE CONGRESS OF THE UNITED STATES:

Science and technology are making the oceans of the world an expanding frontier.

In preparing for the coming decades, we must turn our attention seaward in the quest for fuels, minerals, and food—and for the natural beauty of the seashore to refresh the spirit.

Yet the sea will yield its bounty only in proportion to our vision, our boldness, our determination, and our knowledge.

During the past year we have taken new steps to strengthen the Nation's scientific and technological base for understanding and using the oceans. We have made good progress but much remains to be done in the years ahead.

The National Council on Marine Resources and Engineering Development, chaired by the Vice President, has made significant progress in mobilizing the resources of the Federal Government to meet these challenges. I am pleased to transmit to the Congress the Council's recommendations and annual report.

The Fiscal Year 1969 Budget, which is now before the Congress, includes $516 million for marine science and technology programs. Increased funding is proposed for:

—Broadening education and research in marine sciences, particularly in the Sea Grant and other university programs.

—Speeding up our research for an economical technology for extracting fish protein concentrate for use in the War on Hunger.

—Development of improved ocean buoys to collect accurate and timely data for better prediction of weather and ocean conditions.

—Expanding the Navy's advanced technology needed for work in the deep oceans, and for rescue, search and salvage.

—Constructing a new high-strength cutter for the Ice Patrol and oceanographic research in Arctic and sub-polar areas.

—Preventing and alleviating pollution from spillage of oil and other hazardous ship cargoes.

—Continued mapping of the continental shelf to assist in resource development and other industrial, scientific, and national security purposes.

—Increased research and planning to improve our coastal zone and to promote development of the Great Lakes and of our ports and harbors.

—Application of spacecraft technology in oceanography, and improved observation and prediction of the ocean environment.

Other nations are also seeking to exploit the promise of the sea. We invite and encourage their interest, for the oceans that cover three-fourths of our globe affect the destiny of all mankind. For our part, we will:

—Work to strengthen international law to reaffirm the traditional freedom of the seas.

—Encourage mutual restraint among nations so that the oceans do not become the basis for military conflict.

—Seek international arrangements to insure that ocean resources are harvested in an equitable manner, and in a way that will assure their continued abundance.

Lack of knowledge about the extent and distribution of the living and mineral resources of the sea limits their use by all nations and inhibits sound decisions as to rights of exploitation. I have therefore asked the Secretary of State to explore with other nations their interest in joining together in long-term ocean exploration.

Such activities could:

—Expand cooperative efforts by scientists from many nations to penetrate the mysteries of the sea that still lie before us;

—Increase our knowledge of food resources, so that we may use food from the sea more fully to assist in meeting world-wide threats of malnutrition and disease;

—Bring closer the day when the peoples of the world can exploit new sources of minerals and fossil fuels.

While we strive to improve Government programs, we must also recognize the importance of private investment, industrial innovation, and academic talent. We must strengthen cooperation between the public and private sectors.

I am pleased and proud to report that we have made substantial progress during the first full year of our marine science program, dedicated to more effective use of the sea.

We shall build on these achievements.

LYNDON B. JOHNSON.

THE WHITE HOUSE.

THE VICE PRESIDENT,
Washington.

DEAR MR. PRESIDENT:

I am pleased to forward the second annual report of the National Council on Marine Resources and Engineering Development entitled "Marine Science Affairs—A Year of Plans and Progress."

This report is an account of policies, programs, and accomplishments of the Federal Government for utilizing the oceans more effectively in meeting goals and aspirations of our Nation. The report highlights opportunities deserving special emphasis and details funding requirements for marine sciences included in your Fiscal Year 1969 proposals to the Congress. Finally, the report contains an evaluation of progress toward meeting public needs and identifies impediments to further advancements related to this Nation's stake in the sea.

During the past year the agencies of our Government, separately and collectively, have continued to develop a substantial base of research. And they have focused ideas, facilities, and manpower with a clearer sense of direction and priorities to:

—strengthen our economy by identifying new sources of food, fuel, and mineral resources; by encouraging innovation in marine technology; and by enlarging U.S. participation in the world's maritime activities;

—enhance the quality of urban living by arresting degradation and erosion of the shoreline, fostering urban waterfront development, and expanding water recreation opportunities;

—strengthen world understanding and security through international, cooperative marine endeavors, international legal arrangements to avoid potential conflicts, and an unexcelled naval capability to deter aggression;

—foster education and training of oceanographers, engineers, technicians, and those from other professions through collaboration with and assistance to our universities and technical institutes.

The Council has endeavored to clarify goals, to identify unmet needs and opportunities—especially those of concern to several agencies—and to meet urgent problems by encouraging constructive programs. We have provided guidance for implementing the marine science initiatives that you recommended to the Congress last year.

Finally, we have endeavored to utilize the high quality base of science and engineering within an institutional framework which will insure that new concepts can be translated effectively and promptly into practice—a framework that includes participation by State and local Governments, private industry, and the academic community.

The Council has selected several areas for additional emphasis in Fiscal Year 1969, and is recommending that we:

—inaugurate an expanded program of international ocean exploration;

—intensify our use of Food from the Sea in the War on Hunger;

—promote optimal use of the Coastal Zone with stress on Federal, State, and regional cooperation;

—prepare for improvements to our harbor and port systems;

—institute new measures to insure safety of life and property at sea;

—increase investments in manpower and research, including support of the Sea Grant College programs;

—foster marine applications of new technological developments such as spacecraft, deep ocean buoys, and automatic data processing;

—improve our capabilities to work in the deep oceans;

—expand Arctic and subpolar research;

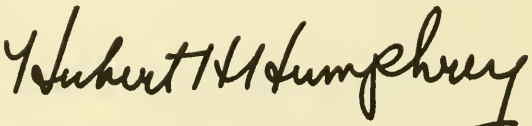
—extend reconnaissance mapping of the Continental Shelf.

There have been many recent reminders that our task has only begun. The world population continues to grow while food supplies stretch thinner. The U.S. has slipped from fifth to sixth place among fishing nations. Oil slicks frequently wash ashore on our beaches. The need for new recreational opportunities becomes increasingly critical as our coastal cities expand and impose new demands on our limited seashores. And attempts by some nations to unilaterally abrogate the traditional freedoms of the seas have threatened long-standing principles of international law.

The Marine Resources and Engineering Development Act of 1966 established a clear mandate for this Nation to employ the sea, as we do the land, to meet the growing needs of our expanding population. I can report to you that with the full cooperation and support of all agencies we shall use our marine resources to respond to the challenge of the decades ahead.

This program is dedicated to the pursuit of excellence. It is proving how the power of science, transformed through our various institutions and the democratic process to a technology, may serve our Nation's diverse interests.

Sincerely,



HUBERT H. HUMPHREY.

THE PRESIDENT,
The White House,
Washington, D.C.

A Report to the President From the National Council on Marine Resources and Engineering Development, February 1968

THIS REPORT TO THE PRESIDENT ON MARINE SCIENCE AFFAIRS is prepared in accordance with Public Law 89–454, the Marine Resources and Engineering Development Act of 1966, which states that the President shall transmit to the Congress an annual report including (1) a comprehensive description of the activities and the accomplishments of all agencies and the departments of the United States in the field of marine sciences during the preceding fiscal year; (2) an evaluation of such activities in terms of the objectives set forth pursuant to Public Law 89–454; (3) such recommendations for legislation as the President may consider necessary or desirable for the attainment of the objectives of Public Law 89–454; and (4) an estimate of funding requirements of each agency and department of the Federal Government for marine science activities during the succeeding fiscal year.

The Marine Resources and Engineering Development Act was amended by P. L. 89–688, the National Sea Grant College and Program Act of 1966, which also requires an annual report by the President on sea grant colleges and programs.

This Report on Marine Science Affairs is submitted to the Congress in response to both requirements. It was prepared by the National Council on Marine Resources and Engineering Development. The Council, located in the Executive Office of the President, is composed of—

CHAIRMAN:

Hubert H. Humphrey, *the Vice President.*

MEMBERS:

Dean Rusk, *the Secretary of State.*
Paul R. Ignatius, *the Secretary of the Navy.*
(Paul H. Nitze until September 1, 1967)
Stewart L. Udall, *the Secretary of the Interior.*
Alexander B. Trowbridge, *the Secretary of Commerce.*
(John T. Connor until February 1, 1967)
John W. Gardner, *the Secretary of Health, Education, and Welfare.*
Alan S. Boyd, *the Secretary of Transportation.*
Glenn T. Seaborg, *Chairman, Atomic Energy Commission.*
Leland J. Haworth, *Director, National Science Foundation.*

OBSERVERS:

James E. Webb, *Administrator, National Aeronautics and Space Administration.*
S. Dillon Ripley, *Secretary, Smithsonian Institution.*
William S. Gaud, *Administrator, Agency for International Development.*
Charles J. Zwick, *Director, Bureau of the Budget.*
(Charles L. Schultze until January 29, 1968)
Arthur M. Okun, *Chairman, Council of Economic Advisors.*
(Gardner Ackley until February 15, 1968)
Donald F. Hornig, *Director, Office of Science and Technology.*

EXECUTIVE SECRETARY:

Edward Wenk, Jr.

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A Report to the President From the National Council on Marine Resources and Engineering Development, February 1968

INTRODUCTION

AMERICA's involvement with the sea began when maritime explorers from Europe discovered and settled this new land. America's utilization of the sea began soon after. Our history reveals cycles of maritime interest and apathy, and today we are re-examining our stake in the oceans in a new context of modern science and technology.

The early seaboard colonies, with a hostile wilderness to their backs, depended for survival on a thread of logistic support 3,000 miles long. As a consequence, this Nation's founding fathers recognized the importance both of the concept of the freedom of the seas and of the necessity for expanding maritime programs and policies.

In the 19th Century we began to explore and develop a continent. Steam power replaced sail; the railroads replaced the pony express; and the people turned their attention to the opening of the West, strictly a land frontier. Interest in the oceans declined.

Only in the 20th Century, as the United States became a great world power, did the importance of the surrounding oceans and of seapower once again become evident. Two world wars demonstrated to the United States that it must have both a strong Navy and merchant fleet.

Since World War II, the Nation has become increasingly aware of the geography of economic and strategic competition, in which the oceans are the principal highways to world trade.

Man's involvement with the oceans is, however, far broader than national security and trade:

—The oceans are the principal source of rainfall.

—They help to stabilize our climate, for the seas gain and lose heat from the sun more slowly than the land.

—They supply food of great variety, rich in protein.

—The seabed contains abundant oil, gas, minerals, and precious metals.
—The coastal zone is a major arena for rest and recreation and the nursery for marine life.
—The entire marine environment serves as a gigantic laboratory of science.

In the middle 1950's, the Government requested a major review by the National Academy of Sciences to assess the importance of oceanography in peace and war. The resulting landmark study treated two important questions:

—Should both naval and civil uses of the sea be expanded to help meet national goals and aspirations?
—Is man's basic knowledge of the marine environment growing in proportion to his diverse requirements?

Answers to these questions were influenced by broad developments in economic and political affairs at home and abroad, and, after 1959, by specific developments in the marine sciences themselves. The United States had become ever more deeply concerned over the danger of conflicts and threats to world order. Simultaneously, advances in scientific research and space exploration had made man appreciate how little he knew of his natural world and impatient to apply science and technology, whenever possible, to the improvement of society.

In the maritime field, a new impetus occurred to explore and exploit the sea. First, a technological readiness began to emerge from broad advances in science and engineering. Next, important new international conventions provided a legal framework more conducive to orderly development of marine resources. Finally, over the past decade, the United States developed a high-quality fleet of research ships, supporting laboratory facilities, and a substantial body of scientific and engineering personnel.

Despite such evidence of progress in the oceans, the Nation remained undecided as to what fraction of its scientific and industrial resources should be devoted to marine science affairs.

In 1966, declaring that the public interest required a clear statement of national determination to utilize the seas and the Great Lakes more effectively, the Congress created a mechanism by which Federal marine science programs would have greater momentum and sharper direction.

It passed the *Marine Resources and Engineering Development Act of 1966, Public Law 89–454.*[1] This measure set forth an unprecedented

[1] Following are some abbreviations and definitions generally used in the marine sciences field:

The Act is customarily called the *Marine Sciences Act.*

The National Council on Marine Resources and Engineering Development is usually abbreviated to the *Marine Sciences Council.*

The Commission on Marine Science, Engineering, and Resources is usually referred to as the *Marine Sciences Commission.*

Marine science is a term employed in Public Law 89–454 to describe scientific

national policy to intensify study of the sea and to convert to practical reality its inherent promise for man's benefit. It reaffirmed the leadership of the President of the United States in marine science affairs. It provided the President with two new instruments of assistance—a policy planning and coordinating Council at Cabinet-level chaired by the Vice President, and an advisory Commission of distinguished citizens to develop long-range recommendations.

As the Act recognized, scientific research, exploration, and development of resources in the oceans must be related to man's activities on land. Thus, while marine science goals, policies, and programs must be examined in terms of unique characteristics of the natural environment which they share in common, they must also be examined in relation to the social environment—the major goals of society and the Nation.

The Chairman of the Marine Sciences Council enumerated many of these relationships between the sea and society when he reported to the Congress that:

> There are one and one-half billion hungry people in the world. The full food potential of the seas, seriously neglected in the past, must be realized to combat famine and despair. Technologies now at hand can be directed toward increasing the world's fishing catch and enriching the diets of the underfed.
>
> Seventy-five percent of our population lives along our coasts and Great Lakes. Nine of our fifteen largest metropolitan areas are on the oceans and Great Lakes, and three are on ocean tributaries. Twenty million children live in these metropolitan areas within sight of potential water recreation areas but are often denied their use. Only three percent of our ocean and Great Lakes coastline has been set aside for public use or conservation.
>
> More than 90 percent by value of our intercontinental commerce travels by ship. Although there have been rapid changes in the character of ocean cargoes and technologies of cargo handling, the average age of our port structures is 45 years and the average age of our merchant ships is 19 years.
>
> The continuing threats to world peace require our Navy to maintain a high level of readiness and versatility through a sea-based deterrent and undersea warfare capability. Middle East conflicts following closure of the Gulf of Aqaba vividly emphasize the urgent need for a strengthened code of international law of the sea.
>
> Thirty million Americans swim in the oceans, eleven million are saltwater sport fishermen, and eight million engage in recreational boating in our coastal States. All these activities are threatened by the dumping of industrial wastes into ocean tributaries. This pollution will increase seven-fold by the year 2000 unless there are drastic changes in waste handling.

---

research, engineering, and technological development related to the marine environment.

The *marine environment* is considered to include the oceans, the Continental Shelf and estuaries of the United States and its territories, the Great Lakes, and the resources of the oceans and Great Lakes.

287-921 O—68——2

> Ocean-generated storms cause millions of dollars of damage annually along our coasts, but marine weather warning services are available to less than one-third of our coastal areas.[2]

The first annual report to the President, entitled *Marine Science Affairs—A Year of Transition,* described initial efforts to respond to these challenges. It emphasized the transition from scientific oceanography to application of these scientific discoveries, and the transition from considerations largely at the program level to a new concern and responsibility at the policy level of Government. The phrase *marine science affairs* reflects the necessity of coupling marine science and technology to the publicly agreed upon needs and desires of our society.

During the past year, the agencies of the United States Government, separately and in collaboration, have made many accomplishments.

The transition to more effective use of the seas has been continued and accelerated.

This Second Annual Report to the President is entitled *Marine Science Affairs—A Year of Plans and Progress.* The first chapter outlines the Government-wide program and approach and highlights new developments. The next six chapters describe Federal programs in marine sciences that serve the following basic needs and national purposes:

—expanding international cooperation and understanding
—accelerating use of food from the sea
—encouraging development of non-living resources
—enhancing benefits from the Coastal Zone
—facilitating transport and trade
—strengthening military programs for national security

The remainder of this report is primarily devoted to activities oriented to serve a variety of purposes, namely:

—understanding and surveying the ocean environment
—information management
—scientific research
—manpower: education, training, and facilities
—engineering in the ocean

Each chapter sets forth priority areas in marine sciences recommended by the Council to the President and reflected in the President's budget for Fiscal Year 1969, now before Congress. To place these special areas in perspective, the report also discusses on-going efforts and associated funding for the Government as a whole, with funding data delineated both by purpose and by agency. Also described are recent accomplishments of the

[2] Letter from Vice President Hubert H. Humphrey to the Honorable Alton A. Lennon, Chairman, Subcommittee on Oceanography, House Committee on Merchant Marine and Fisheries, August 17, 1967.

Federal Government's marine science operations. Finally, the report discusses those recommendations arrived at collectively by the Marine Sciences Council in setting goals, identifying priorities, clarifying agency responsibilities, especially for programs crossing agency lines, and other steps to assist the President to implement the Marine Sciences Act.

The report concludes with a discussion of Federal partnership with non-Federal institutions and with a look ahead.

A number of broad issues are presented in this concluding chapter on "The Nation and the Sea: Questions for the Future." These are intended to illuminate such long-range questions as "What is the Nation's—and the world's—stake in the oceans?" and to guide inquiries in seeking answers.

"There is one thing stronger than all the Armies in the World, and that is an idea whose time has come." —VICTOR HUGO

Chapter I

MARINE SCIENCES AND NATIONAL GOALS

THE Federal Government has continued a broad set of action programs in response to the mandate of the Marine Resources and Engineering Development Act of 1966 "to develop, encourage, and maintain a coordinated, comprehensive, and long-range national program in marine science for the benefit of mankind to assist in:

—protection of health and property,
—enhancement of commerce, transportation, and national security,
—rehabilitation of our commercial fisheries, and
—increased utilization of these and other resources."

This mandate of the Congress and the President further identifies eight objectives related to these goals. Specifically, the marine science activities of the United States should "contribute to the following objectives:

—The accelerated development of the resources of the marine environment.
—The expansion of human knowledge of the marine environment.
—The encouragement of private investment enterprise in exploration, technological development, marine commerce, and economic utilization of the resources of the marine environment.
—The preservation of the role of the United States as a leader in marine science and resource development.
—The advancement of education and training in marine science.

—The development and improvement of the capabilities, performance, use, and efficiency of vehicles, equipment, and instruments for use in exploration, research, surveys, the recovery of resources, and the transmission of energy in the marine environment.
—The effective utilization of the scientific and engineering resources of the Nation, with close cooperation among all interested agencies, public and private, in order to avoid unnecessary duplication of effort, facilities, and equipment, or waste.
—The cooperation by the United States with other nations and groups of nations and international organizations in marine science activities when such cooperation is in the national interest." [1]

Role of the Marine Sciences Council

The Marine Sciences Council, in the Executive Office of the President, assists the President in policy planning and coordination of the activities in 24 bureaus of 11 Federal departments and agencies (see Table I.1) by seeking to: (a) identify unmet needs and opportunities to which Federal marine science programs could be directed, especially gaps resulting from programs that cross agency lines; (b) recommend priorities on a Government-wide basis by selecting areas deserving additional emphasis; (c) identify impediments to progress and strategies for their circumvention; (d) develop policies by which the objectives and programs of one agency will not inadvertently conflict with equally valid but independent activities of another; (e) recommend—in those cases where missions of several agencies may overlap—that one agency assume a lead responsibility for Government-wide planning, guiding, coordinating, and assuring fiscal support; (f) coordinate—through a committee structure—programs which are of concern to many agencies; (g) insure that the appropriate resources of the Federal Government are brought to bear on mutually agreed upon goals; (h) evaluate programs so as to eliminate marginal activities; and (i) develop background legal, economic, and technological studies to help in identifying alternative policies and criteria for choice.

The Council has met 11 times since August 1966. It has developed a number of program and policy recommendations discussed in subsequent chapters. Most of its attention has been devoted to isolating urgent problems deserving priority attention, planning programs, and insuring that necessary funding and leadership are provided.

[1] PL 89–454.

Table I.1—Federal Marine Science Activities

Agency	Mission
DEPARTMENT OF DEFENSE	All phases of oceanography relating to national security.
Navy; Advanced Research Projects Agency; Army Corps of Engineers.	Naval technology.
	Statutory Civilian Responsibilities: Great Lakes, river, harbor, coastal, and ocean charting and forecasting; Great Lakes, river, harbor, and coastal development, restoration, and preservation.
DEPARTMENT OF THE INTERIOR	Management, conservation, and development of marine natural resources.
Geological Survey; Federal Water Pollution Control Administration; Bureau of Commercial Fisheries; Bureau of Sport Fisheries and Wildlife; Bureau of Mines; Bureau of Land Management; National Park Service; Bureau of Outdoor Recreation; Office of Saline Water.	Measurement and enforcement of water quality standards.
	Acquisition, preservation, and development of coastal areas.
	Identification and development of technology for evaluation of mineral resources.
	Identification of sources and interrelationships for supply of fresh water.
NATIONAL SCIENCE FOUNDATION	Basic and academic oceanography.
	Facilities support.
	Sea Grant Colleges and Programs
DEPARTMENT OF COMMERCE	Environmental prediction and description; tsunami and hurricane warning.
Environmental Science Services Administration; Maritime Administration.	Charting and mapping of coastal and deep-ocean waters.
	Central responsibility for air/sea interaction program.
	Research on ship design, shipbuilding, and ship operations.
	Marine transportation and port systems.
DEPARTMENT OF TRANSPORTATION	Safety and protection of life and property in port and at sea.
Coast Guard.	Delineation and prediction of ice masses.
Office of the Secretary	Navigation aids; oceanographic and meteorological observations.
	Transport systems analysis and planning.
ATOMIC ENERGY COMMISSION	Radioactivity in the marine environment.
	Development of marine nuclear technology.
DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE	Human health, healthfulness of food, biomedical research, and support of education.
Public Health Service; Office of Education; Food and Drug Administration.	
DEPARTMENT OF STATE	United States' participation in international organizations.
	Support of international fisheries commissions.
	International marine policies.
AGENCY FOR INTERNATIONAL DEVELOPMENT	Foreign assistance and food resources for developing nations.
SMITHSONIAN INSTITUTION	Identification, acquisition, classification, and ecology of marine organisms; investigations of the geophysical factors of oceanic environment.
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION	Feasibility, design, and engineering of spacecraft and sensors for ocean observations.
NATIONAL COUNCIL ON MARINE RESOURCES AND ENGINEERING DEVELOPMENT	Policy planning and coordination; assistance to the President.

To strengthen these governmental marine science programs, the Council created four interagency committees to coordinate policies and programs and to develop recommendations as to issues requiring Council-level attention.[2] These committees, which report to the Vice President, are:

Marine Research, Education, and Facilities
Ocean Exploration and Environmental Services
Food-from-the-Sea
Multiple Use of the Coastal Zone

Additionally, at the request of the Vice President, the Secretary of State has established a fifth committee on International Policy in the Marine Environment, to serve the mutual interests of the Council and the Department of State.

The Marine Sciences Council's professional staff of 14 persons includes specialists in ocean sciences, engineering, national security affairs, public administration, law, economics, and international relations. The Council staff serves to identify policy issues, to develop and analyze facts, and to propose alternative plans for Council deliberation and action.

More than 40 consultants contribute as needed to the work of the Council.

Council staff maintains communication with many public and private groups—with the Congress, key officials of the Executive Office of the President, Federal and State agencies, industry, the academic community, and professional societies—to insure that considerations affecting all marine science interests are brought to the attention of the Council, and to interpret Government-wide plans and policies. Consultations have also been undertaken with senior policy officials in more than a dozen countries and numerous international bodies with which the U.S. has or contemplates cooperation in marine science policies and programs.

Role of the Marine Sciences Commission

The Marine Sciences Act also provides for an independent advisory Commission on Marine Science, Engineering, and Resources, to be comprised of fifteen members appointed by the President from Federal and State Governments, industry, laboratories, and other marine science institutions, together with four members of Congress designated to serve as advisers to the Commission.[3]

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[2] Details of scope are given in Appendix C. These committees were established on September 18, 1967, as the successors to the Interagency Committee on Oceanography of the Federal Council for Science and Technology.

[3] The President appointed the Commission on January 9, 1967. Dr. Julius A. Stratton, Chairman of the Board of the Ford Foundation, was named Chairman, and Dr. Richard A. Geyer, Head of the Department of Oceanography, Texas A&M University, Vice Chairman. Other members of the Commission are: Dr. David A. Adams,

Specifically, the Commission is charged to "make a comprehensive investigation and study of all aspects of marine science in order to recommend an overall plan for an adequate national oceanographic program that will meet the present and future national needs."

Further, the Commission shall:

—"Review the known and contemplated needs for natural resources from the marine environment to maintain our expanding national economy.

—Review the surveys, applied research programs, and ocean engineering projects required to obtain the needed resources from the marine environment.

—Review the existing national research programs to insure realistic and adequate support for basic oceanographic research that will enhance human welfare and scientific knowledge.

—Review the existing oceanographic and ocean engineering programs, including education and technical training, to determine which programs are required to advance our national oceanographic competence and stature, and which are not adequately supported.

—Analyze the findings of the above reviews, including the economic factors involved, and recommend an adequate national marine science program that will meet the present and future national needs without unnecessary duplication of effort.

—Recommend a Governmental organizational plan with estimated cost."

By Public Law 89–454, as originally enacted, the Commission was required to submit to the President, via the Council, and to the Congress a report of its findings and recommendations not later than 18 months after its establishment. Authority for the Marine Sciences Council was originally due to terminate 120 days after the submission of the Commission's report.

These dates were changed by enactment of Public Law 90–242, which amended the Marine Sciences Act and was signed into law on January 2, 1968. The amendment (a) extended, for an additional six months, the

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North Carolina Department of Conservation and Development; Dr. Carl A. Auerbach, University of Minnesota; Honorable Charles F. Baird, Under Secretary of the Navy; Jacob Blaustein, Director, Standard Oil Company (Indiana); Dr. James A. Crutchfield, University of Washington; Frank C. DiLuzio, EG&G, Inc.; Leon Jaworski, Fulbright, Crooker, Freeman, Bates & Jaworski, Attorneys; Dr. John A. Knauss, University of Rhode Island; John H. Perry, Jr., Perry Publications, Inc.; Taylor A. Pryor, Makapuu Oceanic Center; George E. Reedy, Struthers Research and Development Corporation; Dr. George H. Sullivan, Northrop Corporation; Dr. Robert M. White, Environmental Science Services Administration.

Congressional Advisors: The Honorable Warren G. Magnuson, U.S. Senator from the State of Washington; The Honorable Norris Cotton, U.S. Senator from the State of New Hampshire; The Honorable Alton A. Lennon, U.S. Representative from the State of North Carolina; The Honorable Charles A. Mosher, U.S. Representative from the State of Ohio.

time within which the Commission's report could be submitted, namely to January 9, 1969; and (b) changed the expiration date of the Council to June 30, 1969, in order to insure continued assistance to the President.

Implementation of Fiscal Year 1968 Initiatives

On the recommendation of the Council last year, the President selected nine areas of marine science for priority attention and support during FY 1968. These initiatives are discussed in later chapters, and highlights of their implementation follow:

1. *International Cooperation.*
   - —The United States proposed to the United Nations General Assembly that it establish a Committee on the Oceans to foster international cooperation and to take steps for the evolution of an international legal structure which would enhance exploration and use of the seabed.
   - —During the Latin American Summit Meeting at Punta del Este and in the communiqué following the visit of Japanese Premier Sato to the United States, marine science cooperation was identified as an area for special emphasis.
   - —As the result of efforts by the United States supported by a number of other nations, the International Telecommunication Union set aside radio frequencies for exclusive use in transmitting oceanographic data.
   - —Plans were developed to propose establishment of international marine preserves.
   - —Fifty foreign scientists participated in the global scientific expedition of the OCEANOGRAPHER.
   - —British, Australian, and Canadian divers entered aquanaut training in the United States in preparation for their participation in SEALAB III experiments in the summer of 1968.
   - —Administrative delays in arranging for Soviet fishery research ships to call at U.S. ports have been greatly reduced to promote bilateral research projects of mutual benefit.
   - —Legal studies were undertaken under Council contracts to gain new insight into some of the international problems involved in developing marine resources.
   - —Studies were completed of the marine science programs of other nations and of international organizations.

2. *Food from the Sea.*—This program was established to exploit the untapped food resources of the sea as a new source of inexpensive protein

for the undernourished in the developing nations, especially through Fish Protein Concentrate (FPC). The Agency for International Development was designated to be lead agency for the program; the Bureau of Commercial Fisheries is to develop the necessary technology.

During the past year:

—The Agency for International Development established a new office to carry out its lead agency responsibilities for the new Food-from-the-Sea Program. This office surveyed a large number of countries and selected Chile for pre-investment market surveys.

—FPC produced from hake-like species was approved for human consumption by the Food and Drug Administration.

—The Bureau of Commercial Fisheries planned for the construction of a pilot plant in the Pacific Northwest to produce FPC.

3. *Sea Grant Program.*—The National Sea Grant College and Program Act (Public Law 89–688) was enacted to accelerate training and education of specialized manpower, especially ocean engineers and technicians; to initiate and support applied research; and to disseminate marine science information. To implement the legislation, the National Science Foundation has:

—established a new Office of Sea Grant Programs;

—issued policy guidelines for use by prospective grantees;

—made its first project and institutional awards.

4. *Data Systems Study.*—Because development of marine science and technology depends upon the effective flow of information from producers to users, special attention was focused on means to improve oceanographic data systems. The first phase of a study by the Council was completed under contract, characterizing the "user community," including the increasing needs of State and local governments, scientists, and private industry, and establishing criteria for needed information.

5. *Estuary Study.*—Planning continued for programs using a new laboratory, under the Corps of Engineers, to study estuarine navigation, water quality, shore erosion, and the effects of pollution and natural influences on fish, shellfish, health, recreation, and beauty of the Chesapeake Bay. One important aim of the program is to evolve a multi-agency, multi-disciplinary approach to the general problem of estuaries. This study is closely correlated with pollution studies of the Federal Water Pollution Control Administration and other agencies of the Federal and State Governments.

6. *Surveys of Mineral Resources.*—The objective is to accelerate planning, surveys, and survey methodology related to marine minerals. In FY 1968, new mineral deposits off Alaska were delineated, and surveys were continued off the Atlantic and Northwest coasts. To assist in the orientation of future Federal programs in marine mineral resource development, the Council sponsored a contract study of the economic potential of mineral resources of the U.S. Continental Shelf and Slope.

7. *Ocean Observation and Prediction.*—Increased emphasis during FY 1968 to strengthen ocean observation networks has resulted in:

—initiation of an experimental breaker and surf forecasting service for beaches of southern California for the protection of bathers and coastal commercial fishermen;

—completion of a comprehensive study indicating the technological feasibility of ocean data buoys for monitoring ocean and atmospheric processes;

—establishment of the Regional Center for Tropical Meteorology in the National Hurricane Center at Miami, and strengthening the National Hurricane Center itself, to provide shore communities and industries and marine operators in the tropical Atlantic with improved weather information.

8. *Deep Ocean Technology.*—The increasing requirements for the Navy to operate throughout the ocean environment, and the loss of the U.S.S. THRESHER and of an unarmed nuclear weapon off the coast of Palomares, Spain, pointed up the importance of a strengthened capability for search and salvage systems in the deep ocean. The Deep Submergence Systems Project of the U.S. Navy was accordingly accelerated, and the Deep Ocean Technology program was initiated to develop components for future systems. A standby capability for such emergencies has been established by the Navy.

9. *Subpolar Oceanographic Research Vessel.*—A replacement Coast Guard ship, previously authorized for the International Ice Patrol, was to be specially designed and constructed to permit oceanographic research in subpolar regions. The Congress did not approve funds, and the request is being renewed.

Council Encouragement of Multi-Agency Cooperative Endeavors

With assistance by the Council, member agencies are cooperating to attack a number of problems of priority concern. A few examples follow:

—Interior and Transportation have conducted a comprehensive examination of ways to cope with major oil pollution incidents such as that associated with the TORREY CANYON disaster.

—State and Commerce are attempting to develop new markets for U.S. marine products abroad, including review of export control policies.

—NASA, Navy, Interior, and ESSA are collectively examining the feasibility of satellite observations for marine science.

—The Navy has made available the Transit Satellite Navigation System for use by other agencies and non-Federal interests.

—The Department of Transportation (Coast Guard and Federal Aviation Agency) is developing a national plan of navigation aids for civilian shipping.

Areas of Increased Emphasis for Fiscal Year 1969

An extensive evaluation of marine science activities of the Federal Government was conducted by the Council in the Fall of 1967, with staff assistance from Council Committees, the National Security Council, the Office of Science and Technology, and non-Governmental consultants. The Government-wide program was examined by purpose as well as by agency. As a consequence, the following initiatives in the marine sciences (funded as shown in Table I. 2) have been approved by the President for special emphasis in FY 1969; each is discussed in detail in subsequent chapters.

We plan to:

1. Accelerate our efforts to *Expand International Cooperation in Ocean Exploration*—to encourage all countries (a) to develop their marine science opportunities through cooperative exploration of the oceans and their living and mineral resources; and (b) to develop new patterns of collaboration in the peaceful uses of the oceans that will contribute to sound international policy decisions on marine resource questions. A small planning staff will be established, initially funded by the Marine Sciences Council, to coordinate U.S. exploration activities, including our participation in international endeavors.

2. Intensify the *Food-from-the-Sea* initiative in the War on Hunger—by undertaking market surveys and feasibility studies for Fish Protein Concentrate (FPC) in three countries abroad, and by accelerating development of new technologies for producing low cost FPC.

3. Foster *Rational Development of the Coastal Zone*—by strengthening research, development, and systems studies of pollution, economic development, and conflicting uses of the Coastal Zone. Federal-Regional-State-local cooperation will be intensified, including use of existing statutory instruments such as River Basin Commissions. A special project to study problems of the Great Lakes area will be initiated by the Council.

4. Prepare for new programs for *Port Development and Redevelopment* with preliminary work for a comprehensive planning study—to incorporate new technology in a national port system that will serve ocean shipping of the future, characterized by deep draft vessels, containerization, express and feeder services, and other technical innovations. Attention will be given to relations between harbors and urban renewal and to regional interrelationships including mutual support between harbors.

Table I.2—New Initiatives and Areas of Increased Emphasis FY 1969 [a]

New initiatives and programs for increased emphasis	Financing agency	President's budget FY 1969 (millions)
1. International Ocean Exploration	Marine Sciences Council	.2
2. Food-From-the-Sea	Agency for International Development	3.0
	Interior	3.6
3. Development of the Coastal Zone	Interior	3.8
	Defense	3.0
4. Port Development and Redevelopment	Defense	0.1
5. Safety of Life and Property	Transportation	2.2
	Interior	1.8
6. Sea Grant Programs	National Science Foundation	6.0
7. Marine Applications of New Technology:		
(a) Ocean Observation from Space	NASA	1.6
	Interior	(b .5)
	Commerce	[c].5
(b) Ocean Buoy Development Program.	Defense	1.3
	Transportation	5.3
(c) Strengthen NODC	Multiagency	[c] 0.3
8. Deep Ocean Technology	Defense	7.4
9. Arctic and Subpolar Research Ship [d]	Transportation	14.5
10. International Regional Cooperation	Several Agencies	[e]
11. Marine Research and Technology:		
(a) Basic Research Growth	Defense	[c] 5.1
	National Science Foundation	[c] 3.5
(b) A Study of an Instrumentation Facility	Marine Sciences Council	[e]
(c) Study of Acoustic Frequency Allocation	Transportation	[f]
12. Mapping of the Continental Shelf	Commerce	13.6
	Interior	2.4
Total		79.2

[a] The initiatives or areas of increased emphasis reported herein are agency program totals rather than increments unless noted otherwise. FY 1968 initiatives were reported as increments last year.
[b] Included in the $1.6 million above.
[c] Increment for increased emphasis.
[d] In addition, the Council will initiate studies concerning arctic research needs.
[e] Funds are included as part of other programs and are not reported here because the amounts for marine science cannot be accurately calculated at this time.
[f] Less than $50,000.
[g] Estimated; exact amount to be determined later.

5. Institute new measures to insure *Safety of Life and Property* along our coasts in light of intensified coastal traffic—by (a) implementation of basic recommendations of the Presidential study of oil pollution by contingency plans, research, and new legislation; (b) improved ship navigation systems; (c) establishment of additional safety standards for offshore structures and designation of sea lanes; and (d) establishment of safe procedures and rescue services for civilian submersibles and underwater activities.

6. Increase *Sea Grant Program* investments—for (a) training specialized manpower, particularly ocean engineers and technicians, that will be urgently needed for technological development of marine resources in the 1970's; (b) meeting regional maritime concerns by establishing research and training centers—in State and private universities, community colleges, and technical schools; and (c) disseminating research results to industry and the public.

7. Foster *Marine Applications of New Technology* of benefit to science and industry—by (a) use of spacecraft already programmed for observations of sea ice, currents, temperature patterns, and surface waves; (b) development of buoy technology to collect oceanographic and meteorological data as a basis for later decisions on a world-wide network; and (c) introduction of automatic data processing capabilities at the National Oceanographic Data Center to improve services available to government and non-government users.

8. Intensify work in *Deep Ocean Technology*—to provide a reservoir of advanced engineering knowledge upon which the Navy can draw to meet requirements of future military systems. The same reservoir of technology may contribute to industrial engineering activity and development of deep sea resources.

9. Intensify *Arctic and Subpolar Research* programs—to strengthen U.S. capabilities in these regions of strategic and economic significance. The Council renewed last year's proposal to construct an already authorized Coast Guard ship for both oceanographic research and ice patrol duties, and will initiate studies concerning research needs in the Arctic.

10. Encourage *International Regional Cooperation* in marine science and technology and resource exploration and development. Special emphasis will be put on use of many bilateral and multi-lateral channels to promote regional stability and cohesiveness and to counter concerns about the growing disparity between U.S. technology and the relative capabilities of other nations.

11. Strengthen the Nation's base of *Marine Research and Technology*—by (a) support of educational institutions to accommodate the rising student enrollments in oceanography; (b) planning for national facilities for testing, standardization, and calibration of oceanographic instruments to meet increasing demands for such services; and (c) developing standardized under-

water communications to keep pace with increasing underwater research activities.

12. Continue last year's initiative of *Mapping of the Continental Shelf.* Improved reconnaissance-scale mapping will assist in identifying new mineral, oil, and gas deposits and will contribute to timely private investment in resource development.

The estimated Government-wide cost of these priority programs for FY 1969 is about $79 million.

The Fiscal Year 1969 Program

The total FY 1969 Federal program, military and civilian, totals $516.2 million, up about 15 percent over FY 1968 and about 17 percent over FY 1967. (See Appendix, Table A–1.) [4]

The increase for FY 69 over FY 68 funding results primarily from:

—increased support of priority developments in ocean engineering by the Navy

—a replacement Coast Guard ship equipped for subpolar research

—a new buoy development program by the Coast Guard

—an increase in mapping, charting, and geodesy for military requirements

—research and development related to coastal pollution from ship cargo spillage.

All of the Federal activities identified within the scope of marine science, engineering, technology, or resources development are detailed by major purpose in Table I.3 and by department and independent agency in Table I.4. Figure 1 graphically shows where the Federal marine science and technology funds are spent. Details by Federal organization, major purpose, and function are given in Appendix A.

[4] The scope of programs has been modified slightly to reflect more accurately the coverage intended by the Marine Sciences Act. Some programs are omitted in this year's report which are marine in nature but are not considered to be marine science, such as acquisitions of marine lands and fishing vessel subsidies. To obtain figures comparable to those in last year's report, the following amounts should be deducted from the totals in Tables I.3 and I.4: FY 67—$38 million, FY 68—$8 million, and FY 69—$7 million.

Figure I— The Marine Science and Technology Dollar
(in percent)

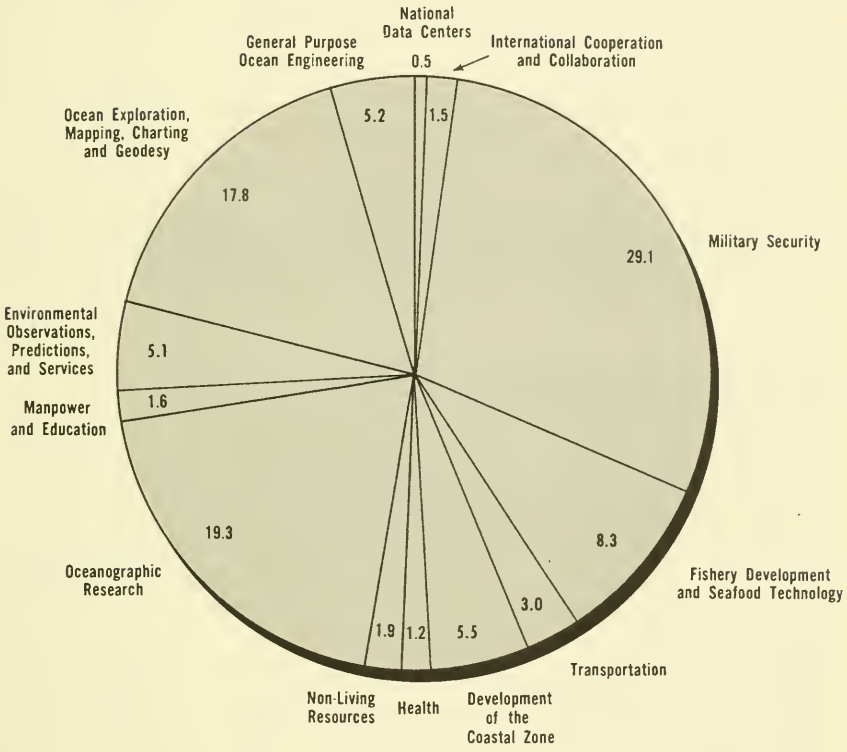

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Table I.3—Total Federal Marine Science Program by Major Purpose [a]

(In millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
1. International Cooperation and Collaboration	7.1	7.6	8.2
2. Military Security	161.8	136.9	150.1
3. Fishery Development and Seafood Technology	38.1	41.2	42.7
4. Transportation	11.9	15.2	15.4
5. Development of the Coastal Zone [b]	21.4	28.7	28.6
6. Health	6.6	5.2	6.0
7. Non-living Resources	7.2	8.1	9.8
8. Oceanographic Research [c]	61.5	78.4	99.7
9. Manpower and Education	4.0	7.2	7.9
10. Environmental Observation, Prediction, and Services	24.4	24.5	26.5
11. Ocean Exploration, Mapping, Charting, and Geodesy	77.4	74.5	92.1
12. General Purpose Ocean Engineering	14.8	18.2	26.8
13. National Data Centers	1.8	2.0	2.4
Total	438.0	447.7	516.2

[a] In this and all subsequent tables, details may not add to totals due to rounding.
[b] Includes Shore Development, Pollution Management, Recreation.
[c] Research beneficial to more than one of the headings above.

Table I.4—Total Federal Marine Science Program by Department and Agency

(In millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
Department of Defense	277.7	256.9	297.7
Department of the Interior	64.1	73.5	75.5
National Science Foundation	24.8	38.3	41.0
Department of Commerce	35.3	38.4	38.1
Department of Transportation	8.3	10.7	33.1
Atomic Energy Commission	11.3	12.7	11.8
Department of Health, Education, and Welfare	7.7	6.4	7.5
Department of State	5.1	5.0	5.2
Agency for International Development	2.0	2.6	3.0
Smithsonian Institution	1.6	1.6	1.7
National Aeronautics and Space Administration	.1	1.6	1.6
TOTAL AGENCY PROGRAMS	438.0	447.7	516.2
National Council on Marine Resources and Engineering Development	(0.9)	(0.9)	(1.2)
Commission on Marine Science, Engineering, and Resources	(0.2)	(0.4)	(0.2)

"Seas but join the regions they divide." —ALEXANDER POPE

Chapter II

EXPANDING INTERNATIONAL COOPERATION AND UNDERSTANDING

THE OCEANS from earliest times have been bonds of commerce and culture. Historic relationships are changing, however, accelerated by advances in maritime technology that enable nations to conduct activities farther from home and in deeper water, and to exploit previously inaccessible resources.

As various national interests in ocean activities converge, international agreements and cooperation will be increasingly needed to reduce conflict and rivalry and to advance world order, understanding, and economic development at home and abroad. The United States has accordingly intensified its efforts to promote international cooperation to attain our major foreign policy goal of establishing a stable and lasting peace.

A multi-national approach to the peaceful uses of the sea is not only desirable but necessary because of the inherently international character of scientific study of the sea and the common property aspect of deep ocean resources. The very size, complexity, and variability of the marine environment emphasize the importance of collaboration.

As a basis for harmonious international marine exploration and resource development, certain premises underlie our policies and programs:

Our knowledge of the seas and their resources is exceedingly limited; the necessary scientific investigations are so vast that international collaboration is essential if knowledge of this environment is to increase within a meaningful period.

Excellence, experience, and capabilities in marine science and technology are shared by many nations in addition to the United States, and cooperation in a number of areas can be mutually beneficial.

In the search for new food resources, the full potential of the seas has not been fully realized.

While very little is known today of the richness and distribution of seabed resources, these resources will eventually be sought to meet a growing demand for energy and minerals.

Technology is rapidly becoming available to permit accelerated marine exploration and resource exploitation.

Development of ocean resources requires major capital investments which in turn require some protection of rights for development and exploitation.

Uncertainties in the interpretation and application of existing international law may result in conflicts of interest between nations, particularly with regard to the width of territorial seas, rights of innocent passage, and the exploitation of ocean resources.

Underlying any legal regime is the need to preserve the traditional freedoms of the seas to permit their peaceful use by all nations.

Our international activities in the marine sciences are thus characterized by:

—encouragement of increased cooperation among ocean scientists of all nations and broadened dissemination of scientific results;

—support of the activities of the many bodies of the United Nations system and other international organizations engaged in oceanic activities and of efforts to improve the international organizational structure;

—collaboration with other nations in developing and using new marine technologies within a framework of mutual benefit;

—making available marine technology and other assistance to complement the efforts of developing countries in strengthening their capabilities to use the ocean and its resources as a pathway to economic progress, recognizing that aid burdens must be shared by other nations and international organizations;

—strengthening of international programs and projects which foster cooperation among neighboring nations to meet common interests and problems;

—pursuit of a strengthened code of international law which will preserve the traditional freedoms of the seas, insure that nations have equitable opportunities to participate in the development of the wealth of the ocean, and anticipate and prevent potential conflicts arising out of expanding maritime interests;

—development of international legal, financial, and political arrangements to promote investment in marine development and facilitate a fruitful partnership between public and private interests in marine matters.

Marine Science in the United Nations[1]

In the United Nations, the General Assembly, the Economic and Social Council, and a number of specialized bodies are responsible for various aspects of marine science affairs, as shown in Figure II.1. In 1967, the General Assembly, at its twenty-second session, began consideration of jurisdiction over the deep ocean seabed [2] and related questions. Fifty-eight countries spoke in the debate and assumed a wide range of positions. Some countries advocated that title to the seabed be vested in the United Nations. Others called for a moratorium on unilateral exploitation of seabed resources. Most countries seemed to feel there should be a freeze on claims of national sovereignty to the seabed. Some maritime nations opposed any consideration now by the Assembly.

The United States, recognizing that understanding of the factors involved in exploiting these resources is incomplete and that we are far from ready to define a precise legal regime at this time, supported careful study of the issue by the General Assembly.

The position of the United States followed the course set by President Lyndon B. Johnson in July 1966 when he said:

> "Under no circumstances, we believe, must we ever allow the prospects of rich harvest and mineral wealth to create a new form of colonial competition among the maritime nations. We must be careful to avoid a race to grab and to hold the lands under the high seas. We must ensure that the deep seas and the ocean bottoms are, and remain, the legacy of all human beings."

The United States proposed that the General Assembly establish a Committee on the Oceans which would be competent to examine all marine questions brought before the Assembly. Such a Committee would stimulate international cooperation in exploration of the oceans. It would assist the General Assembly in considering questions of law and arms control and as a first step might develop a set of principles to govern states in the exploration and use of the seabed.

At the conclusion of debate, the General Assembly took a preliminary step

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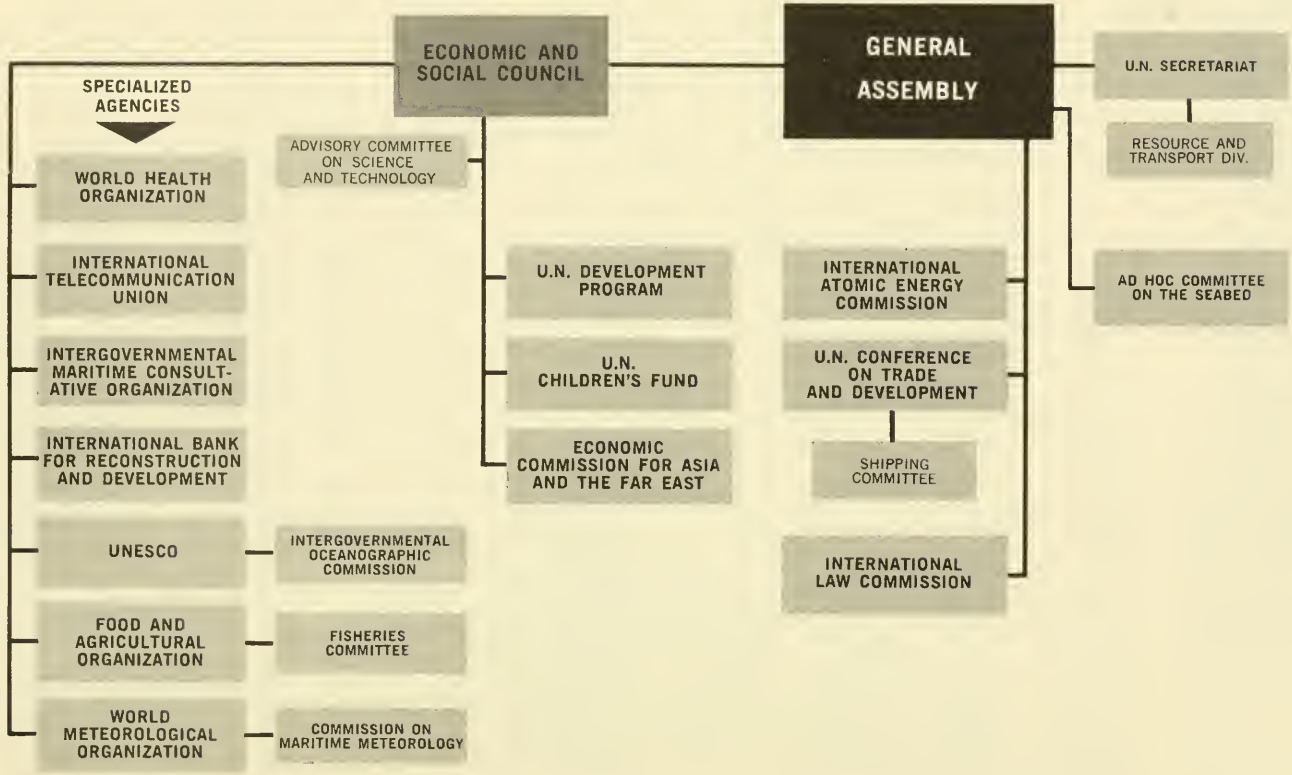
[1] The texts of the 1966 and 1967 General Assembly Resolutions on marine matters are presented in Appendix E, Table E–2.

[2] In this chapter "seabed" refers to the ocean floor and its subsoil seaward of the Continental Shelf as defined in the Continental Shelf Convention.

Figure II-1– United Nations Bodies with Responsibilities in the Marine Sciences



by adopting unanimously Resolution 2340 establishing an *ad hoc* Committee of thirty-five States to prepare a study on various aspects of the seabed beyond national jurisdiction for consideration by the Assembly next fall. The study will include an examination of (a) activities of the United Nations and its specialized agencies related to the seabed; (b) relevant international agreements; (c) scientific, technical, economic, legal, and other aspects of the question; and (d) suggestions regarding practical ways of promoting international cooperation in the exploration, conservation, and use of the seabed and its resources.

Meanwhile, pursuant to the General Assembly Marine Resources Resolution adopted in 1966 as a result of U.S. initiatives, the Secretary General inaugurated a survey of international marine science activities, including consideration of improved coordination between specialized agencies. An international group of experts, convened by the Secretary General, has been requested to outline existing programs and to suggest steps to strengthen international cooperation in the field. The completed report will be used by the *ad hoc* Committee concerned with the seabed and will be presented to the Assembly this fall.

The following specialized agencies and other bodies of the United Nations undertook a variety of new cooperative programs with active participation by the United States:

United Nations Educational, Scientific, and Cultural Organization (UNESCO) and its Intergovernmental Oceanographic Commission (IOC)
World Meteorological Organization (WMO)
International Telecommunication Union (ITU)
Food and Agriculture Organization (FAO)
United Nations Development Program (UNDP)
Intergovernmental Maritime Consultative Organization (IMCO)
Economic Commission for Asia and the Far East (ECAFE)
United Nations Children's Fund (UNICEF)
International Bank for Reconstruction and Development (IBRD)

Some of the programs of particular interest are:

—International oceanographic surveys will be conducted in the Mediterranean and Caribbean Seas, the North Atlantic, and the Southern Ocean (IOC).
—Consideration is being given to a West African marine science center (IOC).
—Attention is being given to the legal impediments to scientific research (IOC).
—Organizational arrangements are being developed for the planning of an Integrated Global Ocean Station System (IOC–WMO).
—Radio frequencies were set aside for exclusive use in the transmission of oceanographic data (ITU).

—The number of UN-supported assistance programs in fisheries and maritime safety is being increased (IBRD–UNDP–FAO–IMCO).

—International measures are under consideration to prevent disasters involving hazardous ship cargoes such as the TORREY CANYON oil pollution spill near the United Kingdom (IMCO).

—Fire safety standards for new ship designs were adopted (IMCO).

—Assistance is increasing to developing nations for their port and coastal development (IBRD).

—Ships are being encouraged to participate in a voluntary weather observation program as part of the World Weather Watch (IMCO–WMO).

—Cooperative off-shore geophysical surveys are being expanded in East Asia (ECAFE).

—International quality standards for fish protein concentrate are being developed (UNICEF–WHO–FAO).

United States contributions to the United Nations and its specialized agencies in support of marine science activities totalled about $3.0 million in FY 1968 and are estimated at $3.1 million in FY 1969. This does not include the activities of the International Bank for Reconstruction and Development.

Other International Bodies

A Convention is now being ratified to establish an International Hydrographic Organization, encompassing the present International Hydrographic Bureau (IHB), to improve coordinated mapping and charting. The United States contribution to the International Hydrographic Bureau was $12,500 in FY 1968 and is estimated at the same level in FY 1969. Additional contributions are made through participation in specific projects. Smaller contributions are also made to many of the other international organizations identified in Appendix E, Table E–1, which serve as coordinating mechanisms in limited areas of marine sciences.

The International Council of Scientific Unions is considering the establishment of a Union of Marine Sciences, consolidating the diverse marine activities of several Unions. In the industrial sector, considerable attention was devoted to off-shore resources during the World Petroleum Congress.

Bilateral Cooperation

Marine capabilities to promote economic development in South Vietnam are being strengthened by such cooperative programs with the Vietnamese

as a major fishery development program through the FAO, a number of port and harbor development projects, coastal and riverine hydrographic surveys, and cooperative oceanographic surveys.

On its global scientific expedition, the OCEANOGRAPHER, carrying the personal greetings of the Vice President, called at 12 ports in 11 countries. Fifty foreign scientists participated on portions of the voyage symbolizing U.S. policy of encouraging cooperative use of advanced research capabilities for mutual benefit.

Following a general policy to make technology developed with U.S. Government funds widely available whenever possible, a number of actions were undertaken: At the invitation of the U.S. Government, British, Australian, and Canadian divers entered aquanaut training in the United States in preparation for their participation in SEALAB III experiments next summer. Specialists from other nations will be invited to observe from the surface. In another step towards increased international cooperation, the Navy Navigation Satellite System (TRANSIT) was released this year for civilian use, and requests for purchase of U.S. receivers from abroad will be considered under munitions control procedures.

During the past year, arrangements were made to turn over to Italy, Korea, Liberia, and India vessels not needed in the United States for marine science activities.

Several Government agencies support marine science activities abroad using excess currencies available under Public Law 480. These programs have been very effective in promoting international scientific activities in such countries as Israel and Tunisia.

International Fishery Arrangements[3]

With more nations looking to the sea for food, some conflicts between nations fishing common stocks are inevitable. During the past year, the United States made special efforts to protect the rights of in-shore coastal fishermen and at the same time to give ample opportunity for high seas fishermen to explore and develop unused fishery stocks. The United States participated in the development of the following international fishery arrangements during 1967:

—extension of agreements with the USSR concerning king crab fishing in the Eastern Bering Sea, fishing gear conflicts off Alaska, and fishing activities off the Washington-Oregon coast; and a new agreement concerning fishing off the mid-Atlantic states;

[3] Fishery conventions to which the U.S. adheres as well as other international treaties in the marine field are identified in Table E–5 of Appendix E.

—an agreement with Japan concerning the new U.S. contiguous fishery zone and king crab and halibut fishing on the high seas;
—an agreement with Mexico concerning fishing of each country in the fishery zone of the other and related fishery data exchanges and cooperative research programs;
—development of new conservation measures under the International Convention for the Northwest Atlantic Fisheries;
—a new program of the International North Pacific Fisheries Commission of coordinated research on ground fish resources;
—designation of the Great Lakes Fishery Commission as the coordinating agency for the alewife program in Lake Michigan;
—conclusion of a Convention on the Conduct of Fishing Operations in the North Atlantic.

The United States contribution to eight international fishery commissions was $2.0 million in FY 1968 and is estimated at $2.1 million in FY 1969. These commissions are responsible for research and management practices concerning fish stocks which provide an annual catch to American fishermen valued at more than $200 million.

Consultation With Other Nations

The President and Vice President discussed international cooperation in the marine sciences with a number of heads of state of Latin America, Europe, and Asia. The President's speech during the Latin American Summit Meeting at Punta del Este and the communiques following the visits to the United States of Premier Sato of Japan and President Marcos of the Philippines identified marine science cooperation for emphasis.[4] The Council's Executive Secretary met with senior policy officials in a number of countries to explain U.S. policies and plans and to encourage policy-level attention abroad on new opportunities to derive benefits from ocean activities through inter-governmental cooperation.

Federal Policy Coordination

Early in 1967, the Secretary of State, at the request of the Vice President, established an *ad hoc* interagency Committee on International Policy for the Marine Environment to develop Government-wide policies and arrange-

[4] The texts of the marine science portions of the speech and communiques are included in Appendix E, Table E–6.

ments. Several temporary panels were established to examine such matters as scientific cooperation, the exploration and use of the mineral resources of the seabed, underseas technology, the living resources of the oceans, regional cooperation in Latin America and Europe, and the national security aspects of these questions. It was this *ad hoc* Committee, for example, which was the mechanism for developing a Government-wide position on the seabed issue considered by the General Assembly. The *ad hoc* Committee has now been converted into a standing committee.

Other inter-agency committees continue to be responsible for the development of United States positions at inter-governmental meetings on such specialized marine matters as the fishery activities of FAO, the fishery commissions, oil pollution, maritime communications, and export of technology.

To insure that new proposals for international collaborative programs that involve several Federal agencies are thoroughly evaluated throughout the Government, procedures have been adopted by the Council whereby a lead agency is designated for evaluating, coordinating, and implementing plans.

The Marine Resources and Engineering Development Act explicitly calls upon the President, with the advice and assistance of the Marine Sciences Council, to undertake legal studies concerned with the management, use, development, and control of marine resources. Thus, three studies by outstanding legal authorities were undertaken through Council contracts, with guidance from the Legal Adviser of the Department of State, on international law aspects of off-shore petroleum, gas, and solid minerals; oceanographic research; and fishing. These will be made available by the Council early in 1968 to facilitate broad examination of the issues.[5]

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[5] Authors of the three studies singled out the following conclusions as being of particular interest. These have not yet been reviewed by the member agencies of the Council, and they will be considered together with other suggested approaches:

—There should be deliberate policy decisions on the extent of the Continental Shelf; a precise definition of its seaward boundary seems desirable. A buffer zone might be established to bridge the boundary between the Shelf and the seabed with the coastal states' interests in the ocean floor given special protection in the Zone.

—The U.S. should seek an international legal framework which promotes freedom of oceanographic research within waters subject to national control and on the Continental Shelf.

—Consideration with regard to living resources might be given to establishment of a global conservation authority which would strive to extend and improve existing international regulation of high seas exploitation in the interest of conservation and efficiency.

Surveys of the marine science activities of other nations, U.S.-funded marine science programs abroad, and marine activities of international organizations were also undertaken by the Council staff. These surveys have highlighted the large number of different ministries involved in marine activities in almost every nation, the variety of U.S.-sponsored cooperative projects throughout the world, and the diversity of the activities of the many international organizations involved in marine matters. Some of these surveys will be released in 1968.

Strengthening International Arrangements

While the previous discussion reflects our immediate concerns, increasing attention is being devoted to longer-term questions and programs, particularly:

1. *A Legal Regime for the Deep Ocean Seabed*

As inter-governmental attention focuses on the seabed, two paramount issues arise: "What should be the seaward limit of the Continental Shelf?" and "What resources are there beyond the Continental Shelf and who should control them?" The work of the *ad hoc* Committee of the General Assembly should contribute to a better understanding of the issues involved while the programs for international ocean exploration described below are intended to provide new insights into resource distribution.

A desirable early step in the evolution of the legal regime for the seabed would be international accord on certain general principles. As already enunciated by the United States, the seabed should not become a stage for a new form of colonial rivalry and should not be subjected to claims of national sovereignty. Rather, the seabed should be open to exploration and use by all states without discrimination. International standards should be set to foster orderly exploration and use of the seabed. Cooperative scientific research of the seabed should be encouraged together with broad dissemination of results. Activities on the seabed should be conducted with reasonable regard for the activities of other states. Pollution and interference with the traditional freedoms of the seas should be avoided.

2. *International Ocean Exploration*

Without more scientific knowledge of the distribution and extent of ocean resources, no nation can optimally develop and utilize them. Our lack of knowledge of the scale and location of ocean resources also hampers the making of sound policy decisions, domestically and internationally, affecting commercial, scientific, and political interests. This highlights the importance of increased scientific knowledge to fuller use of the potential of the oceans and to informed decisions concerning ocean activities.

The United States is thus encouraging the international development of long-range plans for intensified cooperative exploration of the oceans. The past cooperative programs developed by scientists of many nations have already provided many valuable insights of benefit to these nations, and such a long-range program might include new efforts related to geological mapping of the continental margins and deep ocean floor and biological surveys to assess fishery stocks.

All nations are invited to participate in this world-wide endeavor. If other nations join in such an enterprise, existing ocean exploration activities of international organizations will provide an excellent point of departure.

Internal planning for ocean exploration activities of the United States, including participation in international endeavors, is described in Chapter VIII.

3. *Evolving Fishery Arrangements*

The following considerations necessitate further development of fishery arrangements that harmonize broad national goals, conservation needs, and domestic economic concerns:

—There has been a recent increase of foreign fleets fishing in U.S. coastal waters for species which have long been taken by our coastal fishermen. Conflicts often arise because these fleets of large vessels pre-empt the fishing grounds or because the catch by the larger distant water vessels reduces the amount available for United States fishermen.

—The United States fishing industry is lagging behind the industries of other nations.

—International fishery arrangements are increasingly influencing the economic aspects of fishing activities.

—United States distant water fishermen working intensively off the coasts of other countries occasionally raise fears that the local resources are being depleted.

—There is increasing overlap in the geographic areas of concern to the fishery commissions.

—Some nations are sending fishing fleets to areas covered by international fishery conventions to which they do not adhere.

—Finally, the world hunger situation requires further development of the food resources of the oceans.

To strengthen the international legal framework for fishing in the near term, all nations should be encouraged to adhere to the Geneva Convention on Fishing and Conservation of the Living Resources of the High Seas; [6] the complex interrelationships among the many fishing conventions and

[6] Table E–3 of Appendix E lists those countries which adhere to the Geneva Conventions on the Law of the Sea.

among the conventions and the world hunger problem must be better understood; and more attention should be given to the economic as well as the conservation aspects of specific international fishery agreements.

4. *International Marine Preserves*

As man's influence on the natural marine environment increases, there is an urgent need to preserve major types of unmodified ocean habitats for research and education in the marine sciences. Such areas can serve as ecological baselines to provide a basis for comparison in future investigations of the oceans. Therefore, international consideration should be given to the establishment of international marine wilderness preserves. For example, characteristic marine features such as a deep ocean trench, a group of sea mounts, and an uninhabited coral atoll might be set aside exclusively for research and education.

5. *Ocean Acres*

The concept of international ocean acres, i.e. limited ocean areas designated for intensive research over a period of many years, was also endorsed by the Council. Ocean acres might be established in the vicinity of marine preserves or could be established independent of preserves such as the areas in the North Atlantic identified by several nations as of particular interest in connection with the projects of the Intergovernmental Oceanographic Commission.

6. *Cooperation on a Regional Basis*

Marine science and technology offer many opportunities for regional cooperation which can strengthen scientific and economic capabilities and promote regional cohesiveness and stability. Therefore, the United States is emphasizing regional cooperation through more deliberate use of many bilateral and multi-lateral channels.

In carrying out the policy enunciated by the President at Punta del Este to support regional marine science and technology activities, the United States is considering projects related to:

—development of the Plate River Basin;
—regional marine science centers of excellence;
—U.S. support of marine research and education in Latin America;
—cooperative Caribbean research activities.

With regard to Europe, regional marine programs can contribute to strengthening Atlantic alliances, furthering the economic integration of Western Europe, and quickening progress in East-West relations. The United States has discussed in the Organization for Economic Cooperation and Development the possibility of cooperative work in various aspects of marine science affairs and continues to support the activities of the NATO Subcommittee on Oceanography. Also the United States will shortly rejoin the International Council for the Exploration of the Seas.

7. *Collaboration in Oceanographic Research*

During the past year cooperation with the Soviet Union and other countries has increased in oceanography and fishery research. Specifically, there have been exchange visits of oceanographers, reciprocal calls by large oceanographic research vessels, and development of collaborative fishery research projects. A useful step in improving cooperation has been the adoption of a U.S. policy to reduce administrative delays in arranging for Soviet fishery research ships engaged in bilateral research programs to call at U.S. ports. As the tracks of United States oceanographic ships and ships of other nations cross more frequently, expansion of these very modest efforts is essential to eliminate unnecessary duplication and foster availability of data to each other. Such collaboration can make a major contribution to international cooperation and understanding and to effective use of the sea.

The seven above listed international activities provide innumerable opportunities for our marine science programs to contribute to international understanding through (a) joint working projects, and (b) multilateral development of legal arrangements to prevent conflicts. Indeed, the only alternative to international cooperation in oceanic matters is anarchy on the seas.

"The scale, severity, and duration of the world food problems are so great that a massive, long-range, innovative effort unprecedented in human history will be required to master it . . ."—THE WORLD FOOD PROBLEM, REPORT OF THE PRESIDENT'S SCIENCE ADVISORY COMMITTEE, MAY 1967

Chapter III

ACCELERATING USE OF FOOD FROM THE SEA

More effective use of the living resources of the ocean can provide better and less expensive food, enchance economic opportunities at home and abroad, and serve as an important weapon in the world-wide War on Hunger. Our interest in improved utilization of these resources is thus motivated by separate but related considerations.

A strengthened American fishing industry can assist the growth of our domestic economy by contributing to:

—a wider variety of food products for many Americans;
—inexpensive protein sources for low income families;
—more viable economies of coastal communities dependent on fishing, including better paying jobs for American fishermen;
—reduction of the balance of payments deficit by larger U.S. exports of fish products and by improving the competitiveness of the U.S. fishing industry.

Furthermore, if we are to sustain world leadership on a broad front in the understanding and effective use of the sea, strong research and industrial capabilities in the field of fisheries are essential.

Much is known about present and predictable ravages of malnutrition and famine. Yet world food production has barely kept pace with a rapidly expanding population. Protein malnutrition afflicts one-half of the world population—one and one-half billion people. Thus, the imbalance between protein supplies and requirements is so serious that every reasonable ap-

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proach is required to correct it. Accelerated development of food from the sea offers high promise of meeting a part of the world-wide need for protein, and thus assist in:

—reducing threats to world order which are born in areas of starvation and despair;
—extending the humanitarian traditions that underlie our society;
—promoting collaborative efforts between nations in an endeavor of common concern;
—strengthening economies of developing nations which are striving to become contributors to the world economy.

The Marine Sciences Act states that the U.S. marine science program should contribute to rehabilitation of our commercial fisheries and to accelerated development of marine resources. The legislation also singles out international cooperation for special emphasis.

Thus, the Government is endeavoring to strengthen on-going efforts to assist the domestic fishing industry in improving its position in world fishery production through the application of modern science and technology and by economic measures. Also, the United States has embarked on a new, long-range program to exploit the oceans more fully as a source of food to help feed the undernourished people of the world. To that end, our programs follow the broad strategy of the War on Hunger.

State of the Fishing Industry

Since 1956, the United States has dropped from second to sixth place among the fishing nations of the world. While Peru, Japan, Mainland China, the USSR, and recently Norway have increased their landings sharply, the catch of American fishermen has decreased slightly during the last 10 years. (See Figure III. 1.)

The current demand in the United States for all types of fishery products is equivalent to 65 pounds of fish per capita per year, one of the highest rates in the world. The proportion of this demand met by imports has been increasing and in 1966 amounted to about 65 percent of the aquatic products used by the United States. These imports were valued at more than $720 million. (See Figure III. 2.).

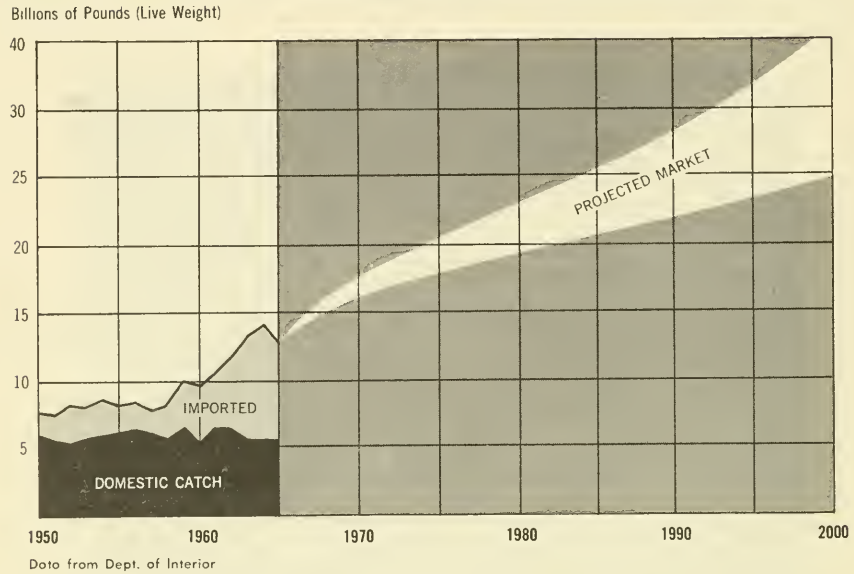
Estimates indicate that the world fishery catch can be greatly increased with presently available techniques. These estimates range from at least a doubling of the catch to a possible increase by a factor of five or more. Of the known species of potential economic value off our coasts, only a few are currently being commercially exploited. Nevertheless, the domestic fishing industry has not expanded, and the rich, latent living resources in nearby

Figure III-1– World Catch of Seafoods by Leading Countries, 1956-1966

NOTE: Live-Weight Basis.

SOURCE: Yearbook of Fishery Statistics—Food and Agricultural Organization of the United Nations; Bureau of Commercial Fisheries; Misc.

Figure III-2– U.S. Market for Fishery Products



Data from Dept. of Interior

international waters are increasingly being harvested by vessels of Asian and European origin.

Numerous interrelated factors bear on this lack of growth of the U.S. fishing industry, and the decline in our international competitive position. Institutional constraints have been cited as a principal cause. Laws, customs, regulations—international and local—may limit the catch of a fisherman or group of fishermen. The restrictions include limitations on the area to be fished, fishing season, type of gear, boats, or the fishing techniques. Regulations may thus be imposed to conserve a sustainable supply of fish stocks; to mediate conflicting user interests, such as between sport and commercial fishing; to insure use of fishing vessels built in the United States; or to insure that individual American fishermen are not at a disadvantage in competing with larger American fishing organizations.

Unfortunately, these regulations sometimes result in serious constraints on the economic efficiency of fishing activities. These constraints contribute to the fragmentation of the industry into small units. A small fishing operation like any small business finds it hard to accumulate sufficient capital to adopt advanced methods and equipment. The fishing industry has not benefited from advantages of large-scale operations and has not developed capabilities to exploit stocks in distant waters except for tuna and shrimp. Some parts of the United States fishing industry increasingly look to investment opportunities abroad where institutional arrangements are considered less burdensome.

With some exceptions, the industry is also fragmented into catching, processing, transporting, and marketing interests rather than providing an integrated fish catching-to-consumption system. Modern marketing techniques are not generally evident. At present the market demand for food fish is largely for species which have been fished for a number of years and which are limited in supply.

Finally, advances in domestic production have been inhibited by inadequate knowledge of fish stock distribution, abundance, and behavior. Consequently, there may be artificial limitations on the species being caught, the areas being fished, and the fishing methods being used. Some resources near the U.S. coast may still be greatly underexploited.

Federal Programs To Assist the Fishing Industry

The Bureau of Commercial Fisheries, cooperating with other Federal agencies and State, academic, and industrial organizations, conducts a variety of programs to foster the economic growth and diversification of U.S. fisheries. The requested appropriation for the FY 1969 fishery development and seafood technology programs of the Bureau totals $42.7 million. These funds provide for a continuation of the following major programs:

1. *Resource development and management:* These programs account for about 63 percent of the funds requested and are designed to gather data to predict abundance and distribution of fish stocks, provide the understanding needed to maintain the harvest at a level of optimum sustainable yield, and obtain information for international negotiations on high seas fishery resources. Among achievements of this program during 1967 were:

—improved prediction of abundance and distribution for skipjack, bluefin, and albacore tuna in the Pacific, and groundfish and sea scallops in the North Atlantic; development of a prediction model for obtaining maximum yield from the Tortugas, Florida, pink shrimp fishery;

—initiation of assessment studies of brown shrimp in the Gulf of Mexico;

—development of lobster and menhaden tagging techniques;

—development of sonar equipment for monitoring salmon migration in Alaskan streams in cooperation with the State;

—continuation of pesticide monitoring along the East Coast and the Gulf of Mexico estuaries;

—completion of two phases of the fishways at Willamette Falls in the Columbia River system;

—successful testing of experimental drifting buoys designed to obtain ocean data at distances up to 400 miles;
—development of spacecraft oceanography for analyzing biologically significant conditions of the ocean;
—coordination of large-scale international investigations of tuna in the Eastern Tropical Pacific.

2. *Processing and marketing:* Research directed to converting raw fish into marketable products accounts for about 20 percent of the FY 1969 budget, including the initiative to expand efforts to develop Fish Protein Concentrate (FPC) described below. During 1967 the following developments were noteworthy:

—assistance in expanding commercial use of Spanish mackerel, soft clams, mullet, and catfish;
—assistance in developing East Coast markets for fish products from the Pacific Northwest by bringing together processors, airline representatives, and buyers;
—approval by the Food and Drug Administration of FPC obtained from hake for human consumption;
—technical assistance to AID in selecting countries to participate in overseas FPC programs;
—development of several new fish products;
—development of irradiation techniques aboard ships to increase the shelf life of fresh fish.

3. *Advanced technology:* The program for the development of new fishing technology is designed to help industry locate fish concentrations more quickly and catch fish more efficiently through new harvesting methods, fishing tactics, and locating techniques. This program accounts for about 10 percent of the FY 1969 budget request.

Achievements during 1967 included:

—development of methods for estimating the size of surface fish schools by aerial photography;
—successful testing of a prototype electrical trawl for harvesting alewives in the Great Lakes;
—development of mechanized seining and conveyer equipment to reduce the time and labor involved in harvesting farm pond fish;
—improvement of midwater trawls and precision depth telemetry systems for harvesting Pacific hake;
—introduction of improved pot gear and preferential bait to expand commercial fishing for crab off southeast Alaska.

4. *Economic research:* Basic economic research and analyses are conducted to aid improvement in economic efficiencies of the commercial fishing industry. This involves all aspects of the fishing industry—management, harvesting, processing, transporting, and marketing. This program accounts for about 4 percent of the requested FY 1969 program. Activities during

1967 included advice to local fishermen in planning and forming fishery cooperatives and coordination of economic research programs at universities on the East Coast.

5. *International activities:* Major changes are taking place in long-established patterns of world fishing. Also, there is a growing interest by the developing countries in expanding fishing capabilities. Details of some of the most significant international fishing programs for which the Bureau has provided the scientific data and technical personnel are described in Chapter II. This type of activity accounts for about 3 percent of the Bureau's FY 1969 budget request.

In addition to these marine science and technology programs, the Bureau of Commercial Fisheries is also responsible for the implementation of three financial assistance programs which are intended to offset, in part, the high costs of ship construction and operation to American fishermen compared to the costs to some foreign competitors. These programs are:

—loans for fishing vessels and gear;

—fishing vessel mortgage and loan insurance;

—fishing vessel construction differential subsidies.

The Environmental Science Services Administration, Atomic Energy Commission, Department of Health, Education, and Welfare, National Science Foundation, and Navy also contribute to better understanding of the potential of the living resources of the oceans. These programs and their FY 1969 budget implications are discussed in other chapters. Of particular interest to the fishing industry are the successful efforts of the Atomic Energy Commission, in conjunction with the Bureau of Commercial Fisheries, in the development of irradiation techniques for fish preservation.

Using Food from the Sea in the War on Hunger

Marine resource development has long been a part of AID programs. Technical assistance has been provided to Korea, for example, for surveys on salmon, oysters, and trout production, and the FY 1968 program calls for further market feasibility studies and technical assistance. The Korean Reconstruction Bank, with loan funds provided by AID, will lend $3 million to Korean fishing cooperatives for the purchase of modern equipment including refrigerator ships and deep sea trawlers. In South Vietnam, AID, in cooperation with the Food and Agriculture Organization, is helping to explore unused fish resources near the mouth of the Mekong River. The program also includes training of Vietnamese in modern fishing technology, production and distribution of fingerlings, construction of fish ponds, dis-

tribution on credit of fishing boats and gear, and construction of fish landing facilities, ice plants, and processing facilities.

In 1967 the United States embarked on a new Food-from-the-Sea program with initial objectives projected over a five-year period as shown in Figure III. 3 to:

—develop commercial processes for producing FPC;[1]
—improve the fish catching, landing, and processing capabilities of three protein-deficient countries;
—develop markets for FPC in at least one protein-deficient country;
—establish a viable commercial FPC system in at least one protein-deficient country;
—encourage other nations and private interests to establish commercial fishing industries in the developing countries.

In carrying out the responsibility as assigned last year as lead agency for the program, AID has established a Food-from-the-Sea Service in its Office of the War on Hunger, and the Bureau of Commercial Fisheries is accelerating necessary technological development.

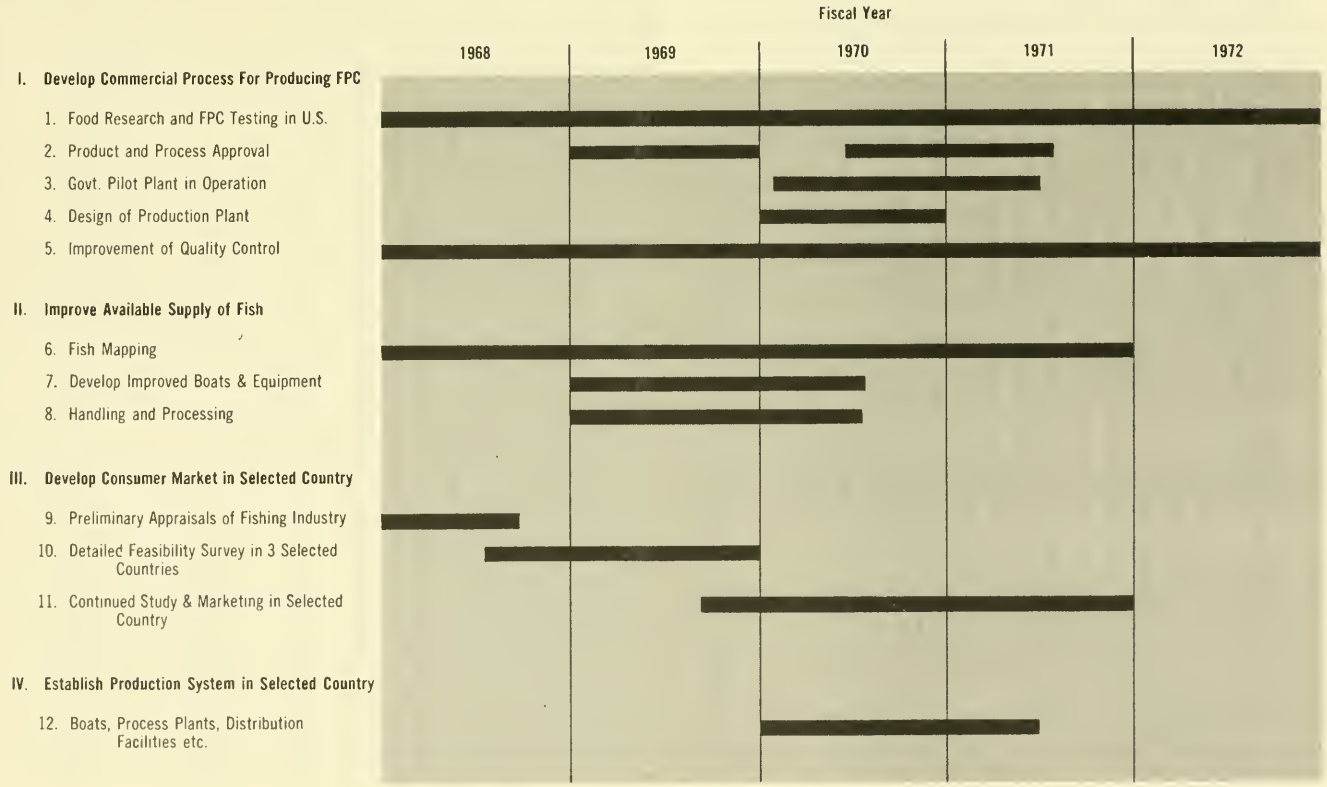
Spearheading this drive to exploit fish resources as a major low-cost item of high protein nourishment for large masses of people are the accelerated efforts of the United States in the development of FPC. Two approaches are involved: assistance to developing countries in exploring possibilities for indigenous FPC production, and the use of FPC produced in the United States in world-wide food aid programs.

Preliminary surveys of the opportunities for developing FPC capabilities have been conducted in a number of Latin American, Asian, and African nations. As a result of these surveys, Chile has been selected for more intensive study to determine whether and in what manner FPC-fortified foods can be marketed commercially. It is anticipated that a country will also soon be selected in Africa and in Asia for similar studies designed to stimulate the market for FPC. These studies will employ modern marketing techniques and will be carried out under contract with private industry. The feasibility studies should provide the basis for determining the potential of FPC, and it is anticipated that the United States will encourage the establishment of an FPC demonstration plant in at least one of these countries as the next step. The studies will also furnish the data and incentives necessary for large-scale investment in FPC industries by the private sector.

During FY 1968, AID plans to purchase about $1 million of domes-

[1] Whole hake and similar abundant species can be converted into a nutritious and wholesome protein concentrate (FPC) that is tasteless and odorless. FPC is bacteriologically and biochemically safe and stable without refrigeration or other special process. Its protein is easily digestible. It can be easily stored and transported and can be readily added to a variety of foods commercially consumed in the developing nations. Ten grams will provide adequate animal protein to meet the daily requirements of one child, at an estimated daily cost of less than one cent.

Figure III-3– Phasing Chart for Food-from-the-Sea Demonstration Program


Fiscal Year
1968
1969
1970
1971
1972
I. Develop Commercial Process For Producing FPC
1. Food Research and FPC Testing in U.S.
2. Product and Process Approval
3. Govt. Pilot Plant in Operation
4. Design of Production Plant
5. Improvement of Quality Control
II. Improve Available Supply of Fish
6. Fish Mapping
7. Develop Improved Boats & Equipment
8. Handling and Processing
III. Develop Consumer Market in Selected Country
9. Preliminary Appraisals of Fishing Industry
10. Detailed Feasibility Survey in 3 Selected Countries
11. Continued Study & Marketing in Selected Country
IV. Establish Production System in Selected Country
12. Boats, Process Plants, Distribution Facilities etc.

tically produced FPC to enrich wheat or a combination of grains provided by the Commodity Credit Corporation for distribution as specially formulated foods in AID's world-wide food programs, primarily for children, pregnant women, and nursing mothers.

AID will initiate a study of the training needs of marine science specialists of the developing nations, including the desirability of establishing an international training center in the United States.

The development of AID's Food-from-the-Sea program has elicited widespread interest in cooperating countries. U.S. industry has shown a great deal of interest in both the production and marketing of domestically produced FPC and in the possibility of construction and operation of FPC plants abroad if AID-sponsored feasibility studies indicate commercial viability.

The Council's Committee on Food from the Sea is concerned with policy guidance and general recommendations for the broad, long-range program to harvest the oceans in every reasonable way as a source of food.

Accelerated Development of Fish Protein Concentrate

In view of the promise of fish protein concentrate as an inexpensive source of protein, engineering development of FPC processing will be accelerated during FY 1969. It is proposed to increase the Bureau of Commercial Fisheries' funds from $1.6 million in FY 1968 to $3.6 million in FY 1969.

FY 1969 efforts will include further refinement of the process for extracting FPC from hake-like species—the process already approved by the Food and Drug Administration. Work to develop processing methods and techniques for extracting FPC from other fish species, particularly oily fish species which are available near protein-deficient nations, will be started. The FPC program in the United States will continue as outlined in Figure III.3.

Supporting Studies

To assist in the development of Government policies to strengthen the domestic fishing industries and the contributions of Food-from-the-Sea to the War on Hunger, the Marine Sciences Council has supported two studies under contract with non-Governmental specialists.

The purpose of the first study was to ascertain whether a systems analysis approach, which has proven valuable in many industries, would be useful

in planning Federal fishery management and resource development programs. A methodology for analyzing optimum fishing systems was developed. Using data provided by the Bureau of Commercial Fisheries, the activities of Boston-based trawlers engaged in exploiting the George's Bank haddock fishery were analyzed as a case study. The investigators concluded that a systems analysis approach can be useful in analyzing the effectiveness of Federal programs—such as subsidy programs in the fishing industry.

The other study surveyed the practice in many countries of aquaculture—the rearing of aquatic organisms under controlled conditions. Scientific and economic factors were evaluated. The authors concluded that aquaculture, and particularly broader development of pond culture, can make a very significant contribution to the War on Hunger. The United States, by virtue of its accomplishments in fields such as ecology, genetics, chemistry, and engineering, can contribute to the development of new and improved techniques in aquaculture. The domestic economy might also benefit from aquaculture through increasing production of high quality food items now considered luxury items because of limited supplies.

The studies are now under review by the concerned agencies, and they will be made available to the public in early 1968.

Looking Ahead

In view of the limited economic viability of the U.S. fishing industry, many recent advances in ocean science and technology are not being as effectively applied by the United States to enhance production of fisheries as by other leading fishing nations. While the programs of the Bureau of Commercial Fisheries described above provide assistance of considerable importance to industry, they cannot in themselves reverse the trend in our declining competitive position in world fisheries.

Of highest priority should be a new concerted effort of the Federal Government, the States, and industry to encourage the evolution of a legal, administrative, and financial framework which harmonizes economic efficiency, conservation needs, and local interests. Given the broad range of overlapping and often conflicting domestic laws and interests, together with the complicating impact of international arrangements, a sharp departure from the limited efforts of the past may be required if there is to be a rehabilitation of the domestic fisheries.

Concurrent with this effort, there will be technological opportunities to strengthen the capabilities of the industry through automation and mechanization on shipboard and on shore; development of new products and new processing, preservation, storage, and marketing practices; and in-

creased knowledge about the nature of fish stocks. Also, aquaculture may offer new keys to enhanced production in the United States.

While FPC offers much promise in strengthening one link of the fish-catching-to-consumption system in the United States and in the developing nations, attention must be devoted to all aspects of the system—particularly market development and harvesting and distribution methods.

The initial goal of the FPC demonstration program is to provide adequate quantities of this food additive by 1971 to meet the animal-protein needs—ten grams per person per day—of at least one million people. Development of the program will, of course, depend on a variety of factors including the success of international marketing programs, industrial contributions to the program, and the pace of technological developments. It has been estimated that if the initial program is successful, a capability could be established by 1975 to provide protein supplement from existing fishing stocks to 7–10 million people. Then, with a self-sustaining industrial base established by 1980, FPC could meet animal-protein needs of over 200 million—using only a small percentage of the projected world fish catch.

The urgency of the problem is clear. The developing nations contain two-thirds of the world's population, and population doubles in most of these nations in from 18 to 27 years. The Food-from-the-Sea program can make an important contribution to meeting their protein needs.

"The ocean is the earth's greatest storehouse of minerals. . . . Our search for mineral wealth often leads us back to the seas." —RACHEL L. CARSON

Chapter IV

ENCOURAGING DEVELOPMENT OF NON-LIVING RESOURCES

Ores, minerals, and fossil fuels are basic sources of the energy, construction materials, metals, chemicals, and fertilizers required by any advanced industrial economy. The United States thus needs continuous access to an adequate, dependable, and economic supply of raw materials to meet demands of an expanding population with a rising standard of living.

Federal policies on mineral resources are designed to contribute to economic development and national security by assisting the Nation in:

—developing adequate and dependable supplies of needed mineral raw materials;

—acquiring mineral supplies at lowest costs consistent with the satisfaction of other national objectives;

—emphasizing domestic supplies of mineral resources to assist in maintaining a favorable balance of payments;

—providing a climate for American industry to produce efficiently, under competitive conditions, the minerals required for the domestic economy and foreign trade;

—conserving the Nation's mineral resources by using them wisely and efficiently;

—preserving the quality of the environment while obtaining needed minerals.

By 1980, the U.S. consumption of non-fuel minerals is expected to double, and that of petroleum products is expected to increase by about 50 percent

from today's base. The United States currently imports 21 percent of its minerals and 13.5 percent of its petroleum; the percentage is considerably higher for certain strategic metals such as manganese. The world-wide demand for minerals also will increase because of industrialization and rising levels of consumption. Such projections create incentives for geological exploration for new reserves and for technological advances to permit use of lower grade sources or substitute materials.

Significance of Offshore Production

Federal policies on solid mineral resources and fossil fuels have traditionally been based on the assumption that the supply would come very largely from land sources. In recent years, however, the grade of minerals from land sources has decreased and production costs have risen. These trends have motivated industry, with the aid of new technology, to turn to the sea for oil, gas, and sulfur, and to begin to look seaward for new sources of aggregates and other materials. This quest, for the time being, is largely pursued in the relatively shallow waters of the Continental Shelf, which approximates 860,000 square miles, one-third of our present land area.

Although little of the U.S. Continental Shelf has been systematically surveyed to determine the presence, distribution, and richness of seabed deposits, this Nation's economy is already benefitting significantly from its resources; this new frontier now provides almost 9 percent of the dollar value of U.S. petroleum production, significant amounts of sulfur, and contributes to national production of other minerals as well. Table IV.1 shows the value of U.S. offshore mineral production. Table IV.2 summarizes recent marine mining activities. Figure IV.1 shows some of the current exploratory drilling around the world.

The value of all minerals produced from Federal and State off-shore waters in the past seven years exceeds $6 billion. The value of petroleum production through 1967 from the Outer Continental Shelf lands (under Federal jurisdiction) has totalled about $4 billion, and if State lands are included, over $5 billion. Since the first Federal off-shore lease sale in 1954, 1,276 oil and gas leases have been sold resulting in a total bonus income of almost $2 billion. Federal royalties from production of oil, gas, and sulfur from the Outer Continental Shelf have totalled more than $700 million through 1967, and the Federal Government now receives more than $12 million per month in royalties.[1]

[1] The Outer Continental Shelf is that portion of the Shelf beyond three miles from the coast, except along the Gulf coasts of Florida and Texas, where it is defined as beyond three marine leagues.

Table IV.1—Value of Mineral Production from Oceans Bordering the United States, 1960–66

[Millions of dollars]

Year	Marine Mineral Production by Source			
	Magnesium metal and compounds, salt and bromine [1]	From wells: Petroleum, natural gas, and sulfur [2]	Sand and gravel, zircon, feldspar, cement rock and limestone [3]	Combined
1960	$69.0	$423.6	$46.8	$539.4
1961	73.0	496.6	46.2	615.8
1962	89.1	620.7	44.3	754.1
1963	84.6	730.8	42.5	857.9
1964	94.5	820.3	43.6	958.4
1965	102.6	933.3	51.4	1,087.3
1966	117.0	1,177.7	49.2	1,343.9
7-year total	629.8	5,203.0	324.0	6,156.8

[1] Sea water.
[2] Ocean subfloors.
[3] Beaches and seafloors.
Source: Bureau of Mines, Department of the Interior.

The petroleum industry's continued confidence in the potential of off-shore production was demonstrated in the June 1967 Federal lease sale off Louisiana which resulted in $510 million in bonuses bid for 150 tracts. Many tracts were in water depths of more than 300 feet; thus the active bidding indicates that industry expects to have technology for operations in deeper water relatively soon.

The Shelf is thus a logical focus for a new era of systematic surveys. The growing world-wide demand for resources, the unexplored areas of the Continental Shelf with geological continuity from adjacent land areas which have yielded great mineral wealth, and scattered positive indications that resources are there, all direct attention to learning more about non-living resources under the sea, as on the Continent itself. See Figure IV.1. Delineation of the distribution and quantity of resources, together with advances in technology to reduce the disparity in costs between on-shore and off-shore extraction operations, will in large measure determine the pace of developing the Shelf. Other factors—legal, economic, and political—will also influence its development in competition with other sources of minerals or their substitutes.

Mineral and fuel resources from land sources are developed almost entirely through private investment and initiative. Private industry is expected to continue to take a similar role on the Continental Shelf.

A major issue thus is presented: How should Federal policies and activities appropriately evolve to enhance and accelerate sound development by private industry of marine resources on public off-shore lands? Should

Table IV.2—Recent Marine Mining Activities

Location	Activity [1]	Depth (feet)[2]	Interest
AFRICA			
Red Sea	Exploration	6,000±	Sulfide muds.
Southwest Africa	Dredging	600−	Diamonds.
Union of South Africa	Exploration	(?)	Phosphate.
ASIA			
Borneo	Exploration	600−	Tin.
India	Exploration	(?)	Phosphate.
Indonesia	Dredging	150−	Tin.
Japan	Dredging	30−	Iron sands.
Malaysia	Exploration	600−	Tin.
Papua and New Guinea	Exploration	600−	Iron sands.
Philippines	Exploration	600−	Iron; gold; titanium.
Thailand	Dredging	150−	Tin.
EUROPE			
Iceland	Dredging	150±	Shell sands.
Great Britain	Exploration	600−	Tin.
NORTH AMERICA			
Bahamas	Dredging	150?	Aragonite.
Canada (B.C.)	Exploration	12,000±	Manganese nodules.
Caribbean Sea	Exploration	200−	(?).
Mexico	Exploration	600−	Phosphate sands.
Pacific Ocean	Exploration	12,000+	Manganese nodules.
U.S.A.:			
Alaska	Exploration	200−	Gold.
Blake Plateau	Exploration	600–2,400	Manganese; phosphate.
California	Dredging	30±	Shells.
California	Exploration (inactive)	600±	Phosphate.
Louisiana	Mining (Frasch)	60±	Sulfur.
New England	Dredging	300−	Sand.
North Carolina	Exploration	600−	Phosphate sands.
OCEANIA			
Australia	Exploration	600−	Phosphate; heavy metals.
New Zealand	Exploration	600−	Heavy metals.
Solomon Islands	Exploration	600−	Tin.
Tasmania	Exploration	600−	Heavy metals.

[1] Dredging operations generally include exploration activity. Does not include mines originating on land and drifted out under the sea floor.
[2] Less than is represented by −; more than is represented by +; approximately is represented by ±.

Source: Department of the Interior.

Figure IV-1– Worldwide Drilling Activity in Offshore Areas (as of June 1967)

SOURCE: Offshore Magazine, June 1967; by permission and with Modifications by Marine Sciences Council.

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the Federal Government support reconnaissance mapping, research and development, and other forms of assistance? What levels of these different activities will, in the next few years, be in the national interest?

Federal Marine Minerals Programs

The Federal program in marine minerals is intended to promote the development of a domestic mineral extraction industry, and to that end the Federal Government plays several distinct roles: It serves as mediator between public and private interests, and it is a source of incentives, economic assistance, and services to industry, as outlined in Chapter XIII.

Facilitating services include:

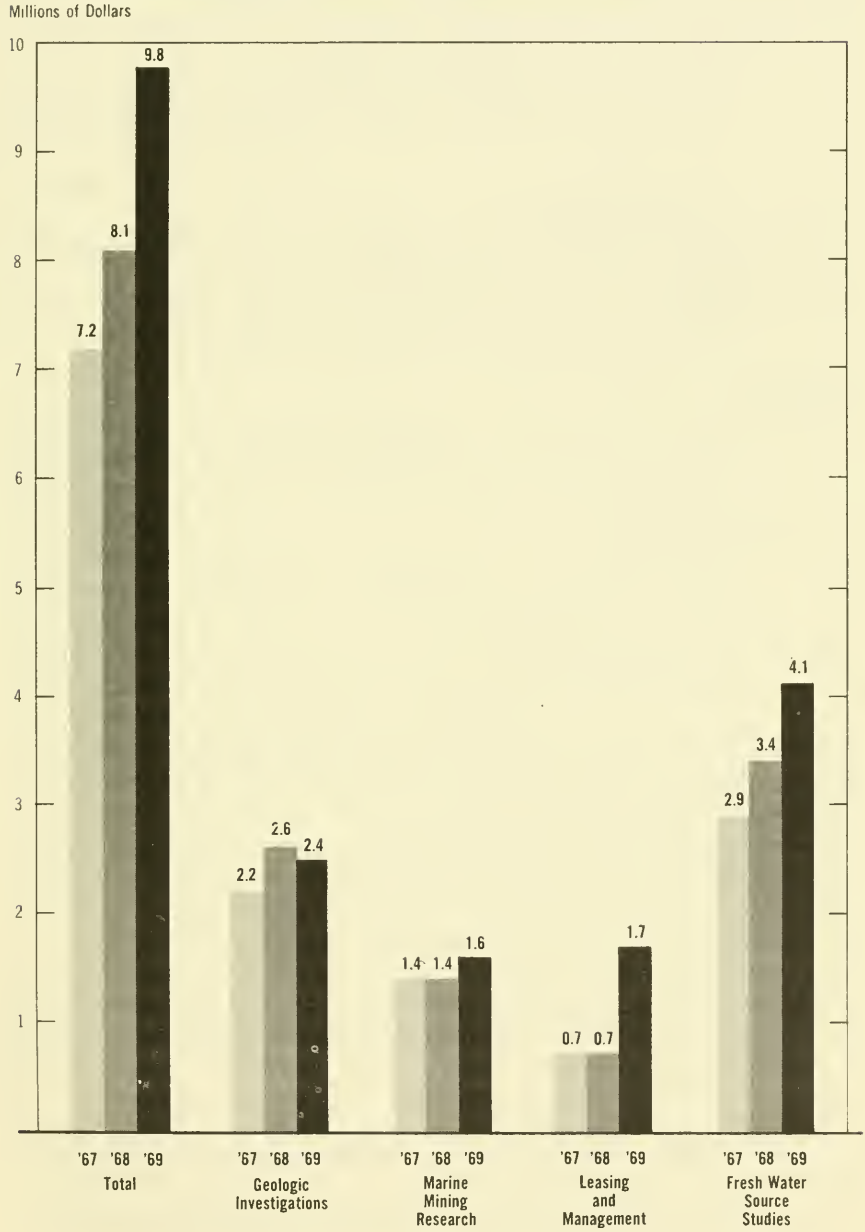
—mapping and charting;
—weather and ocean prediction;
—measures to protect safety of life and property;
—geological surveys to identify potential resources;
—mining research to develop techniques to evaluate potential resources;
—instrumentation development.

Federal programs specifically directed at the development of non-living resources from the marine environment include the marine minerals programs of the Geological Survey and the Bureau of Mines, marine water resource studies of the Geological Survey and the Office of Saline Water, and the resource management functions of the Bureau of Land Management with technical assistance from the Geological Survey.[2] As shown in Figure IV.2, these programs amount to $9.8 million requested for FY 1969, compared with $8.1 million appropriated for FY 1968. Environmental measurements and charting by Environmental Science Services Administration and Navy described in Chapter VIII also contribute significantly to marine minerals development.

Apart from oil, gas, and sulfur, marine mineral deposits of possible economic importance include placer accumulations of the heavy metals (gold, silver, and platinum), iron, titanium, chromium, and tin, and accumulations of phosphorite, glauconite, manganese nodules, and sand and gravel, among others. Marine mineral technology is at such an early stage of development, however, that the resource potential of the seabed has yet to be meaningfully defined. Current efforts of the Geological Survey and the Bureau of Mines are thus directed primarily toward identifying the minerals available from the marine environment, in economic as well as geologic terms.

[2] The Office of Saline Water programs of development and demonstration of desalting methods are not included herein.

Figure IV-2– Federal Investment in Marine Science for Development of Non-Living Resources



1. *The Geological Survey's* marine program is directed to an analysis of the seabed and underlying material on the Continental Shelf and Slope for the purposes of:

(1) appraising the undeveloped mineral, water, and energy resources potential on and beneath the seafloor;

(2) studying marine geological processes to develop new insights about the natural occurrence of resources both on land and on the ocean floor;

(3) evaluating geological and engineering hazards related to seafloor and slope stability;

(4) supplying geological data essential to the management of marine mineral resources and wise land-use planning;

(5) contributing fundamental data on the history and origin of the continental margins and the deep ocean basins.

To accomplish those objectives, the Survey has planned a scientific program for:

(a) providing maps of the Continental Shelf area at a reconnaissance scale (1:1,000,000), utilizing information from all cooperating agencies, from private institutions, and from private industry as available;

(b) providing maps of significant areas of the Continental Shelf at an intermediate scale (1:250,000), incorporating measurements made by all cooperating agencies;

(c) preparation of detailed maps (1:62,500) and analysis of selected areas of high economic potential to be explored in the future on the basis of findings from (a) and (b).

Data from many sources will be analyzed for geological implications. In addition, plans are being drawn to work in deep sea areas, initially for measurements and mapping of areas off Hawaii and island territories, after priority needs under (a) and (b) are met.

The Geological Survey currently supports research in-house, at universities, and at oceanographic institutions, through service contracts with industry, and by cooperative programs with other Federal agencies. Among recent accomplishments of these programs are:

—Reconnaissance investigations of the submerged Atlantic Continental Margin from Nova Scotia to Florida indicated oil deposits on the Continental Shelf and Slope, manganese and phosphate deposits on the Blake Plateau, and sand and gravel off New Jersey and New York.

—On the Continental Shelf of the Bering Sea, the petroleum potential was found to be greater than previously thought, with the discovery there of several large basins.

—In southern Alaska, a study was completed on the effects of submarine

slides and of their locally generated waves resulting from the Alaskan earthquake in 1964.

—On the Continental Shelf of northern California and southern Oregon, acoustical, sub-bottom profiling delineated major faults and late Tertiary sediments. Systematic magnetometer surveys have located concentrations of heavy minerals (some of gold) and of nearshore ancient sedimentary rocks (a common locale of petroleum accumulations).

—In the Gulf of Mexico, the dynamics of formation and sedimentary healing rates of numerous washover scars inflicted on the Padre Island National Seashore by hurricane Beulah were determined.

—Acoustical profiling in San Francisco Bay defined the geometry of the sediments in the central part of the Bay and located several hitherto unknown faults, increasing knowledge of the earthquake hazards to urban development of the Bay area.

2. *The Bureau of Mines* conducts continuing studies of the United States position with respect to consumption, domestic production, and reserves of more than 80 mineral commodities. The Bureau of Mines also examines the economics of minerals production and acquisition from marine and alternative sources. The marine program of the Bureau is designed to assist in the development of technology for the extraction and beneficiation of marine minerals; and the development of equipment and techniques for sampling and delineation of marine mineral deposits. The Bureau is also concerned with identifying the new technology required for economic recovery of materials from the sea. The program, finally, is intended to develop the basis for sound advice on Federal policy concerning ocean mineral leasing and regulation of ocean mining operations.

The Bureau of Mines works in cooperation with private, educational, and Government organizations to improve economic marine mineral production. The cooperative program is designed to provide an opportunity for companies to develop experience in the marine minerals field, crystallize their interests, and determine probable opportunities for their own commercial ventures in the sea through:

—collecting, assembling, and analyzing oceanographic data pertinent to marine mining;

—evaluating and improving techniques for marine mineral sampling and deposit delineation, including participation in research cruises on the Pacific Coast;

—collecting, assembling, and analyzing performance and cost data on dredging and other technology applicable to marine mining.

3. The heavy metals program of the *Bureau of Mines* and the *Geological Survey,* with supporting survey operations provided by the Environmental Science Services Administration and Navy, is directed to stimulating the

domestic production of heavy metals that are in short supply, including gold, silver, platinum metals, mercury, tin, bismuth, antimony, and tantalum. The initial emphasis is on gold, a resource for which the demand is unusually acute. Apart from Government purchases, industrial demand for gold in 1966 in the United States was over three times the domestic output. Projected requirements over the next few decades, considering industrial uses only, indicate a widening gap between demand and domestic supply.

The area off the southern Seward Peninsula near Nome, Alaska, was sampled for undersea placer deposits during the summer of 1967. The test samples contained low but repeated finds of gold in every drill hole, but due to unknown costs of mining offshore in this area, the commercial significance is uncertain.

4. Development of water resources is a major activity of *the Geological Survey.* It investigates offshore fresh water sources and interaction of fresh and salt water in estuaries. Particular attention has been given to the Atlantic Continental Shelf, off Florida, where fresh water was identified in offshore drill holes. Although desalting technology has not been included within the scope of the marine science program, the oceans are an increasingly attractive source of fresh water in some coastal areas. Also, corrosion-reduction technologies developed for desalting programs have broad applications to marine engineering.

Resource Management

The Federal program for exploration, leasing, and development of oil, gas, sulfur, and other minerals of the submerged lands of the Outer Continental Shelf was first authorized by the Outer Continental Shelf Lands Act of August 7, 1953. The Act authorizes the Secretary of the Interior to approve geological and geophysical explorations in the OCS and to grant oil and gas and other mineral leases for further exploration and development of these deposits. Regulation of leasing is administered by the Bureau of Land Management, and the supervision of drilling and production is a function of the Geological Survey.

The Bureau of Land Management prepares leasing maps, recommends lease sales, holds lease sales, issues leases, and approves assignments of lease interests. The Bureau also issues rights-of-way for pipelines and other needed facilities and furnishes technical information for securing final determinations of boundaries between Federal and State jurisdictions. The Bureau's leases contain standard provisions for conservation practices and for protection of aquatic and environmental resources, and any special stipu-

lations that may be necessary for particular situations in consideration of all resource values.

The possible need for improved licensing procedures for minerals other than oil, gas, and sulfur which will protect the heavy exploratory investments required to delineate such minerals is under consideration. This project, together with increased emphasis on evaluation of OCS resources to guide the timing and extent of offerings of tracts for lease bids, will be undertaken by an expanded analytical staff in the Bureau of Land Management.

The Geological Survey's program related to leasing policies includes consideration of: (1) the conservation of mineral resources, (2) the protection of aquatic life and other natural resources of the marine environment, (3) the safety of life and property, and (4) the protection of the public interest by adequate royalty accounting to insure against potential losses in rental and royalty revenues.

The Bureau of Land Management, Geological Survey, and Bureau of Commercial Fisheries recently entered into a Memorandum of Agreement outlining procedures to insure that mineral exploration and development under Department of Interior licenses or permits will be compatible with preservation of marine living resources.

Possible coastal pollution from off-shore industrial activity and safety of these operations are discussed in chapters V and XIII.

Future Development of the Continental Shelf

Despite severe shortages of particular mineral commodities from time to time, supply has historically kept pace with demand. Except for short-term fluctuations, the price of mineral commodities relative to the general price level has not changed. This significant achievement is the result of industrial enterprise and continued advances in the techniques of mineral exploration, production, processing, and utilization.

On land, the lead time from inception of exploration through discovery and development to the beginning of commercial production averages about 15 years. This assumes the existence of regional geological knowledge which generally is lacking offshore. To assist in evaluation of marine mineral resources, the Marine Sciences Council sponsored a contract study of the economic potential of material resources of the U.S. Continental Shelf and Slope. The report is scheduled for completion in early 1968. On the basis of existing data about markets and extraction practices, it was found that at least two decades—perhaps more, depending on the rate of exploration and the development of off-shore technology—probably will elapse before the United States can expect significant production of materials other than oil, gas, and sulfur from the Continental Shelf.

As to oil and gas, there is almost universal agreement that exploration and production offshore will continue to increase to the extent that, by the year 2000, perhaps 25 percent of the world-wide demand will be met by marine sources.

Further, it has been predicted that, over the course of the next 10 years, the oil industry will invest more than $25 billion in off-shore exploration, in 100 different countries. If to this were added the expenditures for off-shore leases and production facilities, annual outlays could well double. This compares with an annual investment now of some $1 billion, on the shelves of all continents. Another $1 billion is invested in off-shore drilling equipment at work around the world. Just 11 years ago the count of off-shore mobile rigs was only 25; last year it had reached 150. We can look forward to comparable growth in the rig fleet in the years ahead.

These projections emphasize the importance of prompt reconnaissance surveys of the Shelf—as a guide to both resource development and to policy formulation. Knowing what is there is a necessary prerequisite to other decisions, public and private, national and international. The Marine Sciences Council has to this end identified as an important next step the completion of geological, geophysical, and bathymetric mapping of the Continental Shelves of the United States at reconnaissance scale.

During FY 1969, resource appraisal activities of the Geological Survey are budgeted at $2.4 million. Bathymetric mapping and other studies of ESSA, which contribute to resource mapping, are budgeted at nearly $13.6 million, and substantial contributions will be made by the Navy. The program also will include participation by universities, research institutions, and industry as well as the Federal Government. The activity has four major aspects:

—production of bathymetric maps of selected areas on a scale of 1:250,000 as a basis for all engineering activity on the Shelf;

—completion of geological and geophysical reconnaissance of the Shelf and Slopes, analysis, and publication of technical studies;

—delineation of the seaward extension of state and national boundaries;

—reduction of time and cost of Shelf surveys through new technology, including automation.

Other marine science needs for eventual development of mineral resources from the marine environment include:

—studies on physical, chemical, and biological oceanography of the water-seafloor system of sedimentation;

—engineering studies of off-shore mining systems;

—chemical understanding of the form of ores recovered from the marine environment and chemical and mechanical engineering of beneficiation processes.

Increased emphasis is being placed by Bureau of Mines on analyses of the demand for and supply of individual minerals and the techno-economics of production from different sources. The experience and judgment of the petroleum and mining industries are being utilized through consultations with policy and technical representatives.

The discussion of non-living resources has concentrated almost exclusively on their extraction from the Continental Shelf in relatively shallow water. How about the deep sea? Any off-shore development, as an extension of land-based activities, depends critically on relative costs. Marine sources will be exploited when the costs are comparable to those on land. Thus, the richness and distribution of the resources and the costs of technology for their exploration and extraction will pace such development. Geological information about the deep ocean seabed is relatively sparse and, in general, the industrial cost for operations in deep water is high. It seems likely, therefore, that the seaward extension of marine mineral development will be a gradual movement from shallow coastal waters to deep waters. Industry might be quickly attracted to the deep sea, however, if rich deposits of a mineral in high demand such as nickel and copper are discovered in the deep sea, or if there are technological breakthroughs.

Coupled to the economic considerations is the importance of a legal framework to encourage large capital investments for which returns may be long deferred. The promise of return from the deep seabed will thus depend significantly on identification and assessment of seabed resources, ready availability of technology from all possible sources including the military, and a stable international code of law.

Many of these objectives can be achieved only by cooperative activities with other nations, as discussed earlier.

"What is the use of a house if you haven't got a tolerable planet to put it on?"
—HENRY DAVID THOREAU

Chapter V

ENHANCING BENEFITS FROM THE COASTAL ZONE

THE marine environment is usually thought of in terms of the visible sweep of vast ocean, of large gulfs, and of broad bays. The part of that environment which is most accessible, and which man uses most intensively, is the Coastal Zone—the margin where land and water meet and interact.

The Zone includes a broad variety of physical features—estuaries, lagoons, wetlands, shoreline beaches of varying widths, cliffs, peninsulas, bays, coastal islands, and off-shore waters on the edges of the seas. The Coastal Zone is also characterized by dynamic interaction of wind, tides, currents, waves, storms—and land; and it supports a rich variety of flora and fauna. The great natural beauty of the shore holds fascination for everyone. Yet this Coastal Zone has values for man other than curiosity and pleasure.

Thirty states, with more than 75 percent of the Nation's population, are on the coasts of the Atlantic or Pacific Oceans, the Gulf of Mexico, or the Great Lakes. More than 45 per cent of our urban population lives directly along the coast, and nine of the 16 largest metropolitan areas are in the Coastal Zone. This population continues to grow and to concentrate—along the East, West, and Gulf Coasts, and the Great Lakes. All of the megalopoli now projected for the year 2000 are in the Coastal Zone.

Shipbuilding, maritime commerce, and the fishing industry could have developed only in the Coastal Zone. The seaward thrust for off-shore oil, gas, and minerals, and our naval strength must be based there. Many

industries have found it advantageous to locate there because of proximity to ocean transport, labor and product markets.

With a burgeoning population that increasingly finds time and money for water-related recreation, the American people have increasingly sought the aesthetic benefits of the Coastal Zone—its temperate climate and opportunities for swimming, sport fishing, and boating. Tens of millions live or vacation at coastal resorts, retirement homes, and beach cottages. Millions regularly head for beaches on weekends. Many others find business opportunities there.

Rational Uses of the Coastal Zone

Thus we seek to use the Coastal Zone in its natural form far more intensively. We also seek to modify it to suit our purposes ever more effectively. As municipalities look increasingly seaward for new habitable areas, or perhaps offshore airports, careful planning of urban and ocean activities becomes essential.

Development of filled-in marshland along estuaries may affect nursery grounds of commercial fish species. Those who dredge and fill along the coasts, or develop harbors, must anticipate changes in shoreline circulation patterns. Sanitation problems associated with ducks, gulls, and other marine birds near populated areas become important. Waste disposal must be related to the assimilation limits of nearby waters.

This area of inshore waters is ecologically fragile and complex in its natural state. It is nevertheless subject to ever more intense pressures for varied uses which may both conflict among themselves and degrade the natural environment.

The scope, diversity, and significance of problems that arise in the Coastal Zone are so broad that practically all institutions of our society have become involved in its management—private individuals who own shoreland, industrial interests, local and State Governments, and the Federal Government.

Only rarely have lands and waters of the Coastal Zone been subjected to planned and controlled development. Further, the planning which has been done has not always resulted in effective allocation of resource uses among competitors. As a consequence, the trend in some places has been toward single-purpose uses, determined by immediate economic advantages to individuals, firms, and local governments. Industrial development; transportation and commerce; oil, gas, and mineral production; private water-

front housing; public recreation; and nature preservation; among others, have all pre-empted Coastal Zone areas without consideration either of harmonious relationships between users or optimum use of a scarce resource itself.

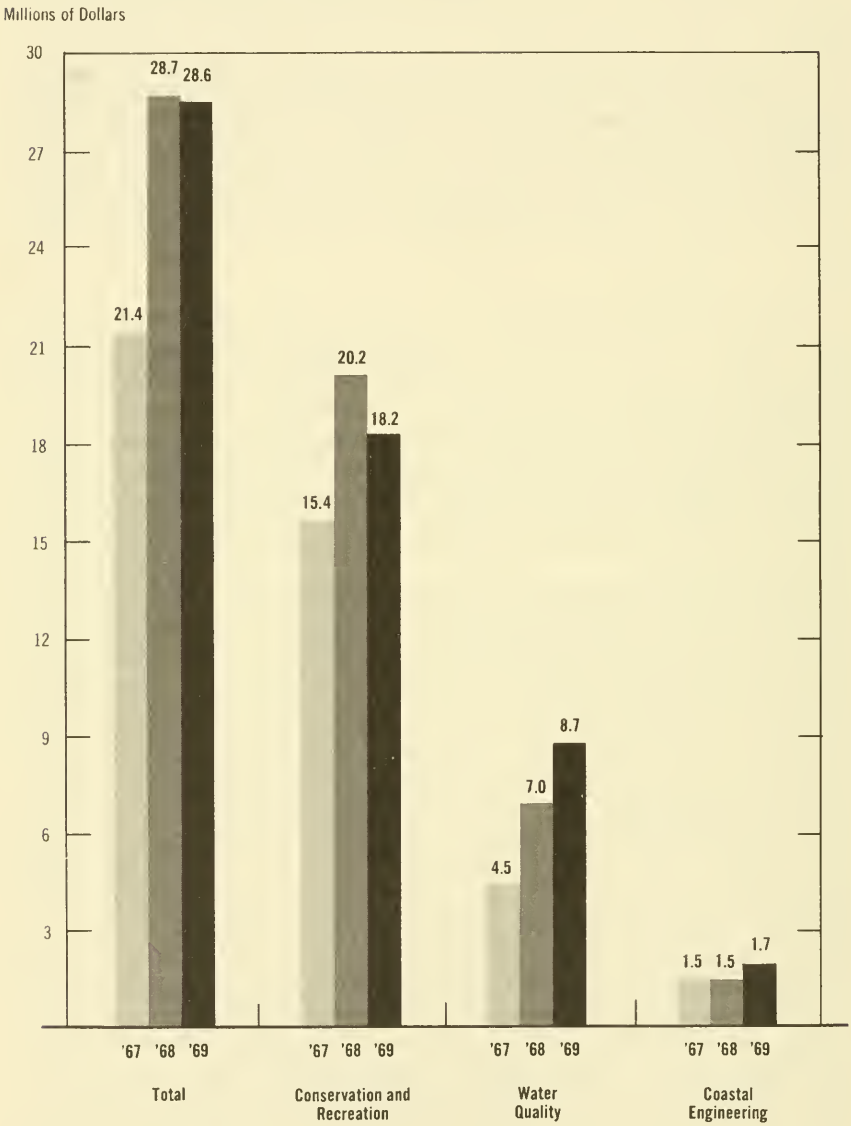
In the early stages of a shoreline's development, single actions may have relatively little impact. But in time, the resource base for certain uses is dissipated. Unplanned expansion of private ownership and development has reduced public access to beaches. The physical destruction of estuarine habitats by dredging and filling have decreased a region's fishing potential; and the pollution of estuarine and coastal waters by cities and industries has begun to destroy much of their usefulness for water supply, fish and wildlife, and recreation.

What we seek are opportunities for multiple, compatible uses of the inshore waters and for maintaining options for future uses not foreclosed by degradation of the resource—first, by identifying alternative uses and multiple compatible uses, and then by encouraging the development of effective mechanisms for rational choices among incompatible uses. Science and technology become the tools to assist in accomplishing explicit goals, predicting possible inadvertent adverse effects, reducing construction costs so as to add to the range of choices, and in evaluating costs and benefits to facilitate choices.

Because of the diversity of Coastal Zone activities in which the Federal Government has a responsibility, almost every member and observer agency of the Marine Sciences Council is directly concerned with the development of the Coastal Zone. Table V.1 summarizes those aspects of the Federal marine science programs which have been classified in this report as activities of the Coastal Zone—coastal engineering, water quality, health, conservation, and recreation. Many other parts of the program discussed in other chapters of the report also indirectly relate to Coastal Zone activities.

As shown in Figure V. 1, Federal funding for these purposes amounted to $21.4 million in FY 1967, and will reach $28.7 million in FY 1968. Appropriation requests for FY 1969 are $28.6 million. Conservation and Recreation is the major cost category and is the one in which the major part of the FY 1968 increase occurred: $20.2 million in FY 1968 as compared with $15.4 million in FY 1967, primarily for developing marine areas for recreation and for conversation of marine locales, gamefish, and wildlife. Another important increase in Federal responsibility, largely stemming from new legislation of 1965–66, has been in water quality management. Some of the most difficult water pollution problems are those in the Coastal Zone—the Great Lakes, estuaries, and other near-shore waters. For water quality management in the marine environment, expenditures in FY 1967 were $4.5 million; funding for FY 1968 is estimated at $7.0 million, and the appropriations requested for FY 1969 to $8.7 million.

Figure V-1– Federal Outlays for Marine Science and Technology, Use of the Coastal Zone



NOTE: Activities in the Department of Health, Education, and Welfare relating to health and Marine pollution were budgeted at: FY 1967, $0.9 million; FY 1968, $1.1 million; and FY 1969, $1.1 million. These amounts are not included in the above totals; they are shown in Appendix Table A–1 under major purpose "Health".

Coastal Engineering

Erosion is a common and often severe form of degradation of the coasts, caused by the action of tides, currents, and hurricane-induced storm surges. Vast areas of valuable land have been lost through erosion, and the land washed away often deposits silt in navigation channels. Erosion may introduce pollutants into the water, and the material deposited may suffocate marine life.

Shore stabilization and protection, carried out by the Army Corps of Engineers, is well established as a Federal function. However, projects are authorized and carried out one at a time in response to local requests, and a longer range approach to setting priorities for such public Coastal Zone works may be needed.

Dredging is essential to waterborne commerce but can damage environmental quality—disturbing the habitat of marine or marsh life. The Corps of Engineers has long had the authority, under the River and Harbor Act of 1899, to deny permits to non-Federal interests for dredging, filling, and excavation in navigable waters if the results would interfere with navigation. Recently, this authority has been interpreted to cover all activities inimical to the public interest. The Secretaries of the Army and the Interior concluded an agreement in 1967 whereby the Department of the Interior will be consulted by the Corps of Engineers when issuance of a permit to dredge or fill in estuaries or other navigable waters is pending. Such coordination permits assessment of fish, wildlife, recreation and pollution problems associated with the proposed dredging.

The Department of the Interior and the Corps of Engineers also have an agreement covering the disposal of material dredged from Federal navigation projects in the Great Lakes area, which is designed to reduce risks of water pollution damage.

Research and engineering studies focused on the requirements for Corps of Engineers construction projects are carried on at the Coastal Engineering Research Center and by contract. Some of the major recent accomplishments include:

—inventory of offshore sand deposits suitable for beach use. Subsurface profiling by sonic techniques and coring of the sub-bottom in 15 to 70 feet of water was completed for selected offshore areas of Florida, New Jersey and California.

—study of improvement of coastal inlets by dredging. Dredging of a deposition basin was completed in the throat of Carolina Beach Inlet, North Carolina; a surveillance program is being carried out to determine the effects the basin will have on the natural channel depths over the ocean bar.

—study of sand movement in the littoral zone by use of radioisotopes. A field trial in California waters was completed using Xenon–133 as a tracer. A detector vehicle with recording system was designed, fabricated, and field tested.

—prediction of currents parallel to the shore. A study was published on both available data and prediction of current velocity from wave and beach characteristics.

In addition, prediction of tides, currents, storms, and storm surges in relation to coastal engineering, are carried out by ESSA. Related research on soil mechanics is also being conducted by the Naval Civil Engineering Laboratory.

Water Quality

Water quality is one of the crucial determinants of the different uses of a coastal area. Moreover, the higher the pollution, the fewer the choices between uses: Reducing pollution may increase options. For particular uses, minimum standards must be maintained. The Federal Water Pollution Control Act, as amended, calls for the enhancement of the quality and value of the Nation's water resources and for the prevention, control, and abatement of pollution. The provisions of the Act apply to the coastal and interstate waters of estuaries, rivers, and lakes.

The Federal Water Pollution Control Administration, which administers the Act, conducts technical studies, engages in comprehensive planning, provides technical services, and participates in enforcement when necessary (at present in 16 estuaries and the Great Lakes). Its comprehensive studies cover the Great Lakes and most coastal areas. The Water Quality Act of 1965 provides for establishment of water quality standards for interstate and coastal waters. The States have submitted proposed standards to the Secretary of the Interior. Primary responsibility for enforcement of the standards, which vary with the nature of the area and the use of the water, rests with the States. If the States fail to act, however, the Federal Government may bring suit against polluters.

The Clean Water Restoration Act of 1966 provided for grants, which may be made by the Secretary of the Interior to States, municipalities, or inter-Governmental agencies, for assistance in developing projects to demonstrate advanced methods of waste treatment, and purification and discharge control. The Act also provided for a comprehensive study of estuaries, including (a) the effects of pollution on various uses of these areas of salt water-fresh water interface, and (b) the effects of population and economic development on water quality. The study began last year and is being con-

ducted on a regional basis by the Secretary of the Interior through the Office of Estuarine Studies, in cooperation with other agencies. The report to the Congress, now scheduled for November 1969, will contain analyses and recommendations relating to estuaries.

The Clean Water Restoration Act called for a study of the nature and extent of pollution from vessels, including disposal of garbage and sewage in navigable waters, and methods of control. The report, "Waste from Watercraft," included numerous recommendations. These are embodied in bills now before Congress to amend the Federal Water Pollution Control Act by setting standards for the discharge of various wastes from watercraft, by providing for the enforcement of these standards, and for certification of devices to control waste discharge.

Additional recent accomplishments from marine science activities related to water quality include the following:

—Interior is investigating and assessing the problems of the disposal of raw sewage, sludge, and polluted spoil in coastal waters, particularly those of the Great Lakes and the Northeast. To support this activity the research vessel CLEAN WATER was purchased to assay water quality.

—In cooperation with several States under the aegis of the Marine Fisheries Commission, Interior is compiling an atlas of estuaries, needed for development and preservation of these areas.

Health

The principal activities of the Department of Health, Education, and Welfare which relate to health aspects of the water quality of the Coastal Zone are concerned with insuring the healthfulness of shellfish and other fish for human consumption, use of the Coastal Zone for recreational and occupational purposes, and use as a disposal site for solid wastes. These activities include (a) conducting and supporting research, development, field investigations, demonstrations, and pilot operations; (b) providing financial and other assistance to State and local programs; and (c) manpower training. Particular emphasis is given to assisting the States in developing their shellfish sanitation programs.

Marine health science facilities serving the coastal areas are now operating in Alabama, Rhode Island, and Washington. Additional construction is underway or planned in the latter two States. These laboratories provide a multi-disciplinary approach to many of the public health problems associated with exploitation of the estuaries and with the production of shellfish and other marine foods from the Continental Shelf. Better understanding of

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the biological and oceanographic factors influencing the public health quality of the marine environment should emerge from these programs.

In 1967, the Water Supply and Sea Resources program of the Public Health Service developed monitoring networks for heavy metals, marine toxins, and other organic pollutants affecting shellfish.

Conservation and Recreation

The National Park Service system now includes 20 areas with significant marine resources—11 national parks and monuments devoted to resource protection and nine national seashores and lakeshores for both protection and recreation. Land acquisition and management is an especially important tool for reserving Coastal Zone space.

The Federal responsibility for conservation of marine locales, game, fish, and wildlife is carried out by the Bureau of Sport Fisheries and Wildlife, Department of the Interior. This involves technical advisory work with other Federal agencies and licensees as well as direct programs of preservation and enhancement of marine areas. Surveys and classifications of estuarine areas are underway in Florida and New York to facilitate prompt review of dredging and other permit applications which might affect marine resources.

The National Wildlife Refuge System includes 42 estuarine refuges, containing 18 million acres devoted to management programs for waterfowl and other wildlife, and particularly preservation of endangered species. Approximately 16,567 acres are scheduled for early acquisition for estuarine refuges under the accelerated Wetlands Acquisition Program.

Reflecting public concern over increasing estuarine damage, Congress is considering legislation designed to inventory estuaries and their characteristics and to protect some coastal areas by establishing procedures for Federal and State acquisition or management of selected estuarine areas and "marine sanctuaries." Also, the Federal agencies have taken administrative actions designed to protect threatened marine species.

The Bureau of Outdoor Recreation plays a central role in promoting Federal-State cooperation and coordination in planning the acquisition and development of both existing and proposed new areas in the Coastal Zone devoted to public recreational use. A Nationwide Outdoor Recreation Plan is being prepared by the Bureau for submission to the President and to Congress in 1968. The Plan will provide a framework for Federal, State, and local and private outdoor recreation programs, including those directed to marine recreation.

The President has directed the Secretary of the Interior to conduct a survey through the Bureau of Outdoor Recreation of the recreation potential of islands off the coastline and on inland waterways of the country, and to suggest principles and guidelines for the conservation of these significant resources. This study is scheduled for completion by late 1968.

The Bureau administers the Land and Water Conservation Fund Act of 1965. Appropriations from the Fund finance the land acquisition program of the National Park Service and help finance the land acquisition programs of the Forest Service and the Bureau of Sport Fisheries and Wildlife. A portion of the funds allocated to each of these agencies has been used to acquire land for public recreation within the Coastal Zone. All States have prepared comprehensive Statewide Outdoor Recreation Plans, many of which include provisions for meeting marine-related recreation needs and the preservation of significant coastal areas. Based upon these plans, the Bureau has assisted over 2,000 State and local outdoor recreation projects.

Many of the shallow estuaries and bays of our Coastal Zone are not used by commercial shipping and, consequently, have never been covered by hydrographic surveys for nautical charting. The increasing use of these shallow water areas by recreational boating and the contemplated conservation activities indicate that these areas should be surveyed and charted. ESSA has initiated a program of surveys and the publication of small craft navigational charts especially suitable for the boating public.

The design for the National Fisheries Center and Aquarium, to be located in Washington, D.C., was approved in 1967 by the Commission of Fine Arts and the National Capital Planning Commission. Detailed design is underway, and construction is expected to begin in Fiscal Year 1969.

Case Studies: Chesapeake Bay and Seattle Harbor

Last year, the Marine Sciences Council considered that the multiple use problems of bays, estuaries, and the Great Lakes required urgent attention, especially to identify more clearly the potential role of science and technology in assisting in the amelioration of conflicts.

As a first step, the Council supported as a major initiative a case study of the Chesapeake Bay. Simultaneously, it decided to focus multi-disciplinary research activities around a laboratory already authorized for the Corps of Engineers for hydraulic and ecological studies that will employ a three-dimensional model of the Bay on a horizontal scale of 1 : 1,000. In view of the large and complex nature of the Bay, the model should aid development of a mathematical framework to predict effects of various measures on

the Bay, thus amplifying empirical measurements made in the past. Also, the model will improve and extend understanding of the physical characteristics of the Bay, the ecology of the environment, and the effects of man's activities on marine organisms. Of particular interest will be understanding of the capacity of the Potomac estuary and subestuaries to absorb pollutants. Studies using such a model cost relatively little compared to large-scale field tests.

Two analytical studies were conducted on contract by the Marine Sciences Council to gain new insights into the implications of Federal policies to enhance optimal use of the Coastal Zone. Results are currently being reviewed and will be made public in 1968. The first study, on the Chesapeake Bay area, directly complements the FY 1968 initiative adopted by the Council. The second study was of the Seattle Harbor area. Each study has catalogued the present use and ownership of waterfront property and considered in some depth financial, legal, and administrative tools available for rational land use planning. Both studies noted a lack of coordinated land use planning at any level—among State agencies and between State and local agencies and the Federal Government—and the need for a data bank concerning the marine environment that affects land use.

The first study also confirmed that because the Chesapeake Bay is used for such a variety of purposes, it is inevitably beset by conflict. For example, because of pollution the Maryland State Health Department has closed some of the oyster beds; public beaches in the Baltimore area must be closed frequently to bathers, also because of pollution; the demand increases for more waterfront land in Baltimore to be devoted to port functions and conflicts with the great need for waterfront recreation; over 11,000 acres of Chesapeake wetlands were irreversibly lost during eleven years (1955–1966), largely due to dredging and filling; and shellfish production has sharply declined, now only 30 percent what it was fifty years ago.

Some of the conflicts on the Chesapeake have been satisfactorily resolved by State and local actions, taken in many cases pursuant to Federal legislation and with Federal sharing of costs. Actions have included adoption of water quality criteria as required by the Federal Clean Water Restoration Act; land planning with development of necessary sewage treatment facilities under the Section 701 program of the Department of Housing and Urban Development; community financing of public works including sewage collection and treatment plants with grant and loan assistance under various Federal programs; proposed acquisition of land on the coastline for public parks, with partial assistance from the Land and Water Conservation Fund; and a pledge by the Maryland Assembly to protect the wetlands.

In addition to these studies, regional economic development studies have been made by the Office of Regional Economic Development of the Department of Commerce pertaining to the Continental Shelf of New England.

The same office also has undertaken a study of the interrelationships of Continental Shelf Resources and regional economic development.

Increased Emphasis

In view of the many benefits and the threats associated with the Coastal Zone, the Marine Sciences Council again selected the Coastal Zone area for priority attention during FY 1969. While this multi-agency effort will build on the initiative of FY 1968 described above, the geographical range of activities will be broadened beyond consideration of the Chesapeake Bay.

During the past year, the Council established an inter-agency Committee on the Multiple Uses of the Coastal Zone to consider this category of issues for the Council. In addition to a continuation and strengthening of the individual agency programs, increased emphasis will be given to the following endeavors:

1. An improved study and planning capability for dealing with problems of the Coastal Zone on a multi-disciplinary, multi-agency basis will be developed within the Committee. Information and plans will be exchanged on:

—environmental data needed for policy decisions concerning the Coastal Zone;
—establishment of ecological baselines along the coasts;
—requirements for monitoring Coastal Zone phenomena;
—human and ecological factors in establishing quality standards;
—scientific and engineering requirements to abate coastal degradation.

Data available from State activities will be used.

2. A long-term multi-agency plan of research on the Chesapeake Bay will be formulated, continuing and broadening the FY 1968 initiative. A comprehensive research facilities plan will be developed concurrently with the design of the Corps of Engineers hydraulic model.

3. The need will be examined for programs in partnership with the States to deal with problems along coastal reaches on the Continental Shelf and the Great Lakes. A pilot program of study of the research needs related to the Great Lakes will be undertaken by the Council in collaboration with the Great Lakes Basin Commission, bordering States, and other inter-governmental authorities considering all uses of the Lakes.

4. Needs for a national estuarine study will be examined to assess the magnitude of estuarine use problems and remedies.

Federal-State Cooperation

We have noted the uniqueness of marine science affairs of the Coastal Zone—resulting from intense, varied human uses super-imposed on an intricate, delicate ecology, and involving an array of governmental entities to manage the Zone. This severe administrative fragmentation, as well as the confrontation between different interests, suggests the need for unifying concepts by which we can deal with these problems.

To isolate local problems and help remedy them, heavy emphasis is anticipated on Federal-State collaboration.

Two considerations may serve as guidelines to future collaboration. The first is that problems vary from one locality to another and involve such finely detailed relationships that some governmental authority lower than Federal must be involved. The second is that mechanisms must be sought to facilitate transfer of study and research to action—both to reduce delay and insure authenticity of interpretation of studies.

Much can be accomplished in promoting optimal use of the Coastal Zone by increased emphasis on existing capabilities and on the use of existing authorities. In some cases, however, new authorities may be needed to attain the needed emphasis on the Coastal Zone. For example, the River Basin Commissions [1] will, as part of comprehensive basin planning, consider steps needed in the estuarine Coastal Zone. However, additional administrative actions or a Commission similar in make-up to the River Basin Commissions may be needed to carry out such measures along the coast between estuaries, and extending out to include related activities on the Continental Shelf.

In order to maximize the benefits from the Coastal Zone, additional actions need to be examined with the two-fold purpose of developing:

—increased public awareness of the nature and importance of the Coastal Zone; and

—an integrated program of science, technology, and public administration to develop more profound understanding of the coastal regions, to sharpen our awareness of biological interdependence, and to plan and implement measures and mechanisms for carrying out a policy which will open new opportunities on the one hand, and preserve that which is best in the environment on the other.

It is now also apparent that while the Federal involvement in the uses of the Coastal Zone has been growing, an institutional framework for management of specific segments of the Coastal Zone as regional entities may be needed if we are to realize the maximum social benefits from this vital natural resource.

[1] Established by Water Resources Planning Act, PL 89–80.

"I hold to be fundamental that . . . our citizens shall be safe in freely traversing the ocean, that the transportation of our produce, in our own vessels, to the markets of our own choice, and the return to us of the articles we want for our own uses, shall be unmolested." —THOMAS JEFFERSON

Chapter VI

FACILITATING TRANSPORT AND TRADE

ABOUT 90 percent of United States foreign trade of $56 billion per year moves by water. Although commercial air transportation between continents has become significant since World War II, it still represents less than 10 percent of total cargo traffic and its cost (per ton mile) is 40 times that of ocean shipping.[1]

The future of the United States in international trade depends on many factors and on their interactions, some subject to influence by Federal policy and program decisions.

As the nations of the world become industrialized, the near-monopoly of the United States in the world market for many manufactured products is disappearing. At the same time, the world market for both goods and services will expand as increasing industrial production creates new mass purchasing power. The net consequence for this Nation could be growing opportunities in foreign trade if American enterprise identifies and capitalizes on comparative advantages.

Some predictions of the total foreign trade picture are optimistic, reflecting the possibility of a doubling of trade every 20 years.[2] Assuming that

[1] The cost per ton-mile of comparable cargo (i.e., general cargo in break bulk shipping) is 18–19¢ for air transport and about ½¢ for sea transport.

[2] U.S. Department of Commerce, Maritime Administration projections, based on the assumption that foreign trade bears a fixed percentage relationship to the Gross National Product show about 1200 million long tons in the year 2000 as against about 300 in 1963.

the trend continues, and that the share of water carriers in U.S. trade continues, the absolute volume of cargo tonnage arriving and departing from United States ports could increase several-fold during the balance of the century.

Such future potential must be considered however, in the light of three present realities: U.S. foreign trade is increasing;[3] the ratio of exports to imports has recently decreased;[4] and the portion of our foreign trade carried by United States flag vessels is decreasing *rapidly*.[5]

How fast this increase in trade will occur and how much of it will travel in United States vessels, will depend considerably upon the policy of the Federal Government with respect to ocean transportation. Such policies will certainly recognize that foreign trade has an important impact on the national economy and that the cost of shipping is a significant factor in market competition. Transportation of foreign trade cargoes by U.S. flag carriers contributes to establishing and maintaining a more substantial "maritime presence." This latter consideration is intangible and difficult to evaluate. Moreover, the national defense role of our ports and our merchant marine is significant and undergoes continuing critical review in relation to changing strategic concepts. New concepts and configurations, with particular reference to performance characteristics of rapid loading and discharge and vessel speed underway, have military reserve utility added to their worth for commercial service.

On economic grounds, international trade is increasingly competitive. Both suppliers (shippers) and markets (consignees) are ever more alert to opportunities for cost-savings, time-savings, and service advantages which may yield indirect savings or product preference.

Marine science and technology can and should help in realizing all of these opportunities, particularly in achieving greater flexibility and adaptability in the transport system as a whole and ultimately in enhancing the competitive position of the United States in world trade. Trends toward specialized ocean transportation services are based on economies which depend heavily on technological innovation. Understanding the system and orienting marine science activities toward system improvements will become increasingly important.

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[3] Total water-borne U.S. foreign cargo trade almost trebled between 1950 and 1966; Source: *Statistical Abstract of the United States.*

[4] Ratio of exports to imports (in tonnage terms) decreased from 1.55 to 1.42 between 1950 and 1966; Source, *ibid.*

[5] The percentage of total U.S. water-born foreign cargo trade carried by U.S. flag vessels decreased from 39.3 to 7.3 percent between 1950 and 1966; Source: *ibid.*

The Ocean Transportation System

To determine where research and development may have greatest payoff, it is helpful to consider United States foreign trade cargo movement as a system of components including physical facilities, manpower, energy, institutional arrangements and policy.

The complete transport system includes five links, of which the three middle ones make up the ocean transport system:

—U.S. land carriers—and domestic water carriers—serving U.S. ports;
—U.S. ports with their cargo-handling equipment, storage facilities, piers, and channels;
—the ocean carriers, U.S. and foreign flag, is scheduled "liner" services and in specialized and "tramp" services;
—the foreign ports;
—connecting transportation networks abroad.

The characteristics of the components making up the ocean transportation system are substantially influenced by a number of supporting activities, including:

—shipbuilding;
—weather and mapping services;
—navigational aids and nautical charting;
—channel dredging;
—search and rescue;
—foreign freight forwarding;
—flow and control of cargo containers.

The ocean transportation system, as it serves U.S. foreign trade, is affected by a number of institutional controls or other influences, including notably:

—Federal Maritime Commission regulations;
—labor agreements and practices;
—customs regulations and operations;
—rate tariffs and rules of conferences (carrier associations);
—rules of the road and other navigational controls;
—other safety-at-sea provisions;
—pollution abatement regulations;

The ocean transport system, its technical components, and their operation and control are linked and influenced by a framework of such Federal actions as:

—subsidies to support construction in U.S. shipyards of vessels for operation under U.S. flag on essential foreign trade routes, intended to make the capital cost of vessels to the U.S. operators roughly equal to those of foreign flag carriers building abroad;
—subsidies to U.S. flag carriers contracting to operate on specified foreign trade routes, intended to equalize certain major operating

costs as compared with foreign flag carriers crewing with foreign nationals, who are free to buy subsistence and supplies, maintenance and repairs, and insurance at best advantage in the world-wide markets;

—federal channel and harbor development;

—cargo preference provisions reserving to U.S. carriers all domestic water traffic (cabotage) and certain foreign traffic in which the Federal Government has direct interest;

—research and development in transportation systems and equipment.

The performance of the system can be evaluated by its costs and products. Costs include expenses of manpower, motive power, capital plant, loss and damage to cargo, loss and damage to vessels, life and other property, and public expenditures associated with ocean transport. Products relate to loads carried, distances traversed, time elapsed, and rates charged.

System Performance: National Significance

The cost incurred by actual movements of cargo is the most significant yardstick of performance. The cost of transportation for a shipment of $30,000 of medical supplies from Chicago, Illinois, to Nancy, France, was analyzed by the Maritime Administration as an illustration of relative opportunities for savings by stages in the overseas shipment. The breakdown of the $2,386 transport cost by stages was:

U.S. domestic	14%
U.S. port	36%
Ocean shipping	25%
European port	18%
European domestic	7%

Thus, about 60% of the total delivery cost accrues in the U.S. port and ocean shipping stages.

Principal opportunities for cost reduction in the U.S. maritime transportation system through the application of marine science and technology appear to be:

Ocean Shipping

- Reduction in capital costs of ships
- Reduction in operating costs
- Reduction in maritime accidents of all kinds (including oil spillage)
- Increased speed of ships
- Improvements in aids to navigation
- Improvements in navigational charting

United States Ports

- Reduction in costs of channel dredging and maintenance
- Reduction in costs of cargo handling
- Increased speed of cargo handling
- Reduction in pilferage
- Reduction in space requirements for terminal facilities

To the extent these opportunities may be realized, the resulting benefits are:

—improved service to shippers (frequency, speed, convenience of routing);

—increased contribution to commerce by inducements to traffic that would not otherwise occur;

—increased U.S. maritime presence and reduction in the U.S. balance of payments deficit by larger U.S. flag participation in our foreign trade;

—better articulation of port functions with other urban activities resulting in improved economic effectiveness in the use of port space and in enhanced habitability around the port areas.

In addition to potential contributions to the merchant marine, research and development for improved ship design may contribute to domestic fishing, development of non-living resources, and ocean exploration. A very large proportion of the cost for scientific expeditions and military or commercial ventures at sea goes for vessel construction and operations so that any advances in merchant vessel economy and performance pay multiple dividends.

The technological characteristics of maritime transport are changing, and they interact with the institutional framework in such matters, for example, as ship automation. Research and development directed toward the above opportunities should increase the range of options open, define trade-offs with respect to both dollar and social costs, and assist in the most appropriate ordering of decisions.

As noted above, port terminals are a critical element of the system. Thus, consideration of maritime commerce encompasses the other needs for waterfront property occupied by ports (usually in the heart of large cities) and maritime development related to urban development and renewal.

Federal Activities in Maritime Transportation Development

The Federal Government provides essential research, planning and safety services and support systems to facilitate private maritime transportation. To put these activities in perspective, some $40 billion in water-borne U.S. foreign trade is supported by a group of Federal activities costing about

$800 million annually.[6] Less than two percent of that amount is directly expended on Federal research and development activities as discussed in this chapter to improve and support the transport system.[7]

Agencies with principal responsibilities in maritime transportation research and development are the Department of Transportation, the Maritime Administration (Department of Commerce), Federal Water Pollution Control Administration (Department of Interior), and the Army Corps of Engineers. Their science and technology activities encompass in general:

—system-wide research and planning (Office of the Secretary of Transportation);
—navigational aids and other safety measures (Coast Guard);
—technology for shipbuilding, vessel design and operations, and cargo handling (Maritime Administration);
—research and technical development on control and cleanup of pollution from oil and other hazardous cargoes (Coast Guard and FWPCA);
—research and engineering in support of channel and harbor development (Army Corps of Engineers).

Federal marine science expenditures in the ocean transportation area for FY 1969 are budgeted at $15.4 million. Funding data by general categories are presented in Figure VI.1, and details by specific categories are given in Table A.1 of Appendix A under Transportation, and in selected line items under Development and Conservation of the Coastal Zone in the same table.

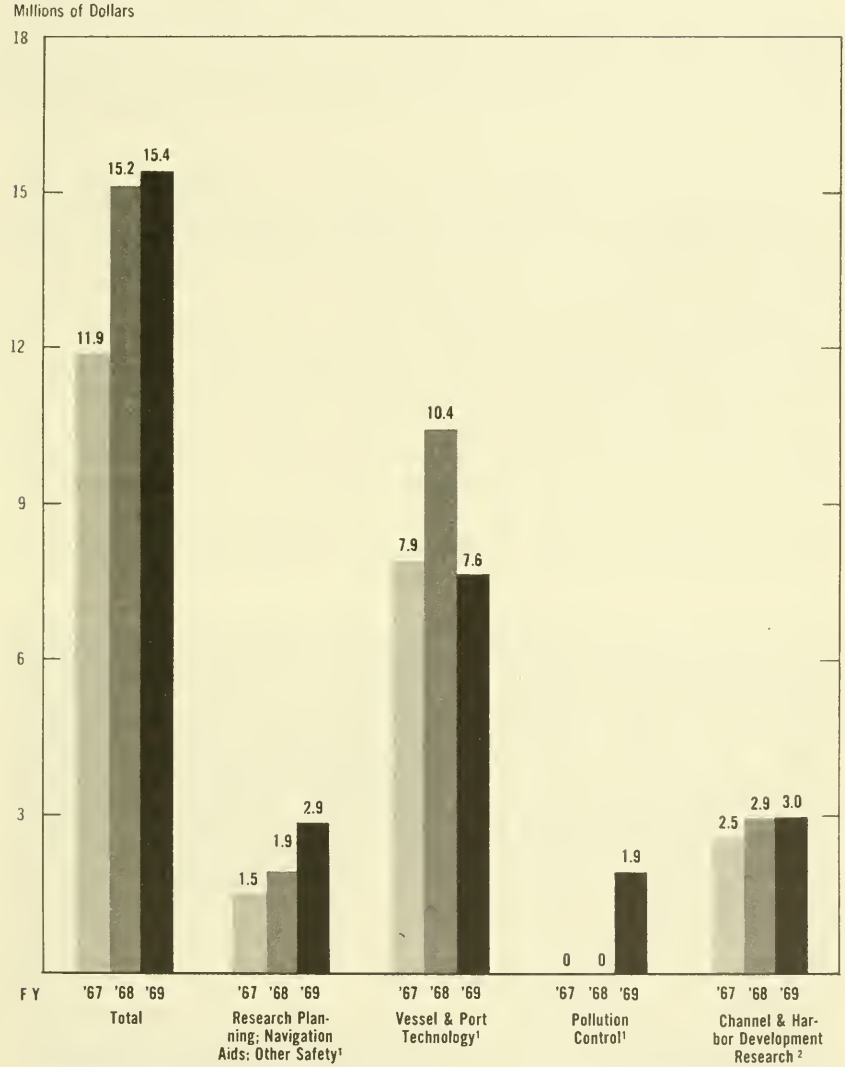
Planning and Research

The Department of Transportation has basic planning and research responsibilities with respect to the total domestic and international transportation systems. The larger-scale inter-modal and multi-modal issues of policy, facilitation, and systems analysis are evaluated in the Office of the Secretary. Sub-systems and services, particularly those concerned with a single mode of transportation, are planned, designed, and operated by major branches within the Department. By such planning, sea transport is considered within the broad framework of a transportation system that includes truck, plane, rail, pipeline, and other modes.

[6] Including (FY 1967): $327 million for Maritime Administration; $177 million for channel and harbor development; $240 million for Customs Bureau; selected activities of the Coast Guard; and other miscellaneous Federal support to shipping.

[7] Not included is an appropriate allocation of Navy research and development expenditures as applied to ship design (not included in the marine science program) and related nautical charting and safety activities of Navy and ESSA mentioned elsewhere.

Figure VI-1– Federal Marine Science Funding for Ocean Transportation



[1] Limited to R&D and scientific services; excludes funding for capital works or maritime subsidies, operations and routine services. Pollution control item here does not include funds of the Department of the Interior (FWPCA) for pollution control. These funds are included as a part of "Water Quality Enhancement" under Development and Conservation of the Coastal Zone in Appendix A financial tables. These amount to $1.8 million in FY 1969, an estimated $1.1 million in FY 1968, and 0 in FY 1967.

[2] Limited to R&D, feasibility studies, and Great Lakes data collection and analysis; excludes funding for expenditures on design, construction, or operation and maintenance activities.

Navigation and Safety Aids

The Coast Guard has primary responsibility for safety of shipping—a requisite to efficient and effective operation of the total maritime transport system. The safety problem is underscored by the fact that in 1966, United States registered vessels operating throughout the world and foreign vessels operating in United States waters suffered more than 2400 collisions and other serious casualties.

Accurate all-weather navigation is necessary for shipping to avoid collisions with rocks, other vessels, and fixed structures, and is also a prerequisite to rational ship routing to avoid adverse weather and operate most economically. New technology is making a major contribution to this function (see Figure VI.2).

Long-Range Navigation (LORAN-A and C) stations, by which a ship may determine its position in the open sea more accurately than before, now service the major shipping lanes. As a result of recent Navy declassification and reductions in costs of commercial receivers, the TRANSIT satellite navigation system (with a precision of about one-tenth of a mile) holds further promise for ocean safety. This position-fixing equipment is independent of the vagaries of electrical atmospheric or cloud interference.

The Coast Guard is also modernizing and automating navigation aids such as lighthouses through the use of remote telemetry systems.

Figure VI.2. *The mainstays of the Coast Guard, its patrol ships, illustrate operational innovations in maritime science and technology. The U.S.C.G. HAMILTON, for example, employs two turbine engines which enable it to attain speeds in excess of 20 knots. (U.S. Coast Guard photograph.)*

Meteorological satellites that provide weather information for ship routing may before long permit the sensing and direct transmission of data on weather fronts.[8]

The safety of small craft at sea is jeopardized by drift, as the tides, currents, and winds combine to move vessels in unintended directions. Information developed by the Bureau of Commercial Fisheries, the Navy, and other Federal and non-Federal agencies, has been used by the Coast Guard in preparing drift tables, which are being continually refined as further experiments are conducted.

Another important safety measure is the establishment of sea lanes designed like divided highways to reduce the incidence of collision in areas of heavy traffic. The Federal Government, assisted by the maritime industry, has established such lanes at the approaches to New York Harbor and Delaware Bay and has approved sea lanes for the approaches to San Francisco Bay. Studies are in progress for the Chesapeake Bay area and are proposed for Cook Inlet, Alaska. An analogous action in the Gulf of Mexico—undertaken by the Corps of Engineers, ESSA, and Coast Guard in cooperation with the shipping industry and the offshore mineral industry—has led to establishment and charting of "fairways" leading to the principal ports of the Gulf in which the erection of structures is not permitted.

The Coast Guard now has programs in 55 ports for control of movement of vessels within navigable waters, ranging from requiring notice of arrival to escorting vessels which pose high hazards (for example, those transporting explosives).

Technology for Maritime Cost Reduction

Based on the analysis of the shipping system outlined earlier, current programs for the application of new vessel and cargo handling technology are focused on two general problems: first, improvements of the port-ship system will result in greater efficiency of cargo handling operations, provide the opportunity for reduced port facility space requirements, and make possible shorter turn-around times; second, improvements in ship design will pro-

[8] Five agencies are cooperating in developing design specifications for a navigational and traffic control satellite system with the principal goal of relatively simple, low cost aircraft and shipboard transponder installations. The agencies are the National Aeronautics and Space Administration and the Departments of Commerce, Defense, Transportation and Interior. NASA will be conducting engineering tests of two separate satellite position location experiments in 1968, i.e., the Interrogation, Recording, and Location System (IRLS) on Nimbus B, and the Omega Position Location Experiment (OPLE) on the ATS satellite. The latter system operates in conjunction with the Navy's OMEGA stations.

duce greater efficiency and effectiveness in ship operation, and perhaps lower capital costs for ocean-going ships.

To these ends, the Maritime Administration has prepared three preliminary model simulations for evaluating ocean transport vehicles, studying the optimization of barge-feeder systems, and analyzing the financing of ships and shipping. Research directed to construction of sophisticated models for analyzing shipping demands and competing supply systems is planned.

The development and use of containerization is perhaps the single most important trend in international transport—affecting interchanges between transport modes and efficiency of carriage by each mode. By using container vessels, shipping lines can significantly reduce the number of port calls and time spent in port. A single automated terminal occupying a small space can take the place of large facilities which use substantial amounts of valuable waterfront land, if rapid transfer to carriers or to in-transit storage away from the waterfront can be provided. Most U.S. ports are not yet adapted to serve container traffic efficiently, as is the port shown in Figure VI.3.

Research and development on containerization has been proceeding for some time, through both private and Government efforts. The results have proved sufficiently promising to bring into service 40 United States flag container ships to date. Moreover, about 100 container ships are now under construction or on order, world-wide. These developments have occurred in spite of the fact that the full potential benefits of containerization have not yet been achieved.

Figure VI.3. *First of the 30 leading U.S. ports to be highly automated to handle container traffic efficiently was Port Elizabeth, New Jersey. Most authorities call the development and use of containerization the single most important trend in international transport. (Photo courtesy of Traffic Service Corporation.)*

Research and development on experimental advanced craft has led to the development and testing of both hydrofoils and surface effects ships (SES). The experience over the last 15 years indicates a limited range of missions, such as fast patrol boats, for which hydrofoils are suitable. Hydrofoils and SES craft are being used in some situations in regular commercial service in Europe, but economically feasible applications of either of these advanced vehicles have not yet been clearly identified and demonstrated in the United States on any substantial scale.

Studies of shipboard operations at sea have focused on ship control, ship maintenance, and ship propulsion. The ship control study considers various engineering and human factors in all ship movements. The possibility of manpower reductions—from the standpoint of operating effectiveness—of the order of 50 percent has been demonstrated, based on the technical feasibility of automated aids to engine room controls. Cost reduction in ship maintenance is being approached through improved and simplified designs of components. Reductions in fuel costs are being sought through improvements in hull forms (such as the bulbous bow), propeller designs, and power plant efficiency. Other technical developments include computer programs to introduce detailed consideration of ship motions into feasibility studies and preliminary designs, leading to construction of ships that can sustain higher speeds in rough seas; and a control-and-design manual to permit better consideration of ship maneuverability in design, a factor which is increasingly important as merchant ships grow larger.

The N. S. Savannah has demonstrated the technical feasibility of nuclear powered merchant vessels, including operating reliability, over-all operational capability, and versatility. The Savannah continues in operation, by charter to a commercial operator, demonstrating operating characteristics in scheduled commercial service. The Maritime Administration has undertaken additional studies of high-speed, nuclear-powered merchant ships, taking into account future nuclear core developments, potential cost of nuclear refueling, and characteristics of particular applications—such as a long distance service by a high-speed containership.

Oil Pollution Control

The transport of large quantities of oil by ship has long posed substantial potential dangers. Legislation on oil pollution has existed in the United States for several years, and the problem has been under careful technical surveillance by the Federal Government. Widespread recognition of the severity of damage that could result from oil spills came only after the tanker Torrey Canyon went aground off the United Kingdom in March, 1967. The

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disaster prompted widespread discussion and stimulated international attention to:

—the desirability of positive traffic control, especially near shore, of tankers and ships with hazardous cargoes;

—stricter enforcement of restrictions against routine dumping of bilgewater after cleaning tanks;

—cooperative measures to contain or control accidental spills and those resulting from dumping.

At the direction of the President, during mid-1967, the Secretaries of the Interior and Transportation conducted a study of oil pollution and its effects, present capabilities for preventing spills and controlling or correcting damage, and steps that might be taken to avoid the consequences of oil pollution. As an adjunct to the Presidential study, the Coast Guard inspected four tanker hulls, sunk on the U.S. Continental Shelf during World War II, for the possible existence of residual oil.

The Coast Guard, Army Corps of Engineers, and Federal Water Pollution Control Administration jointly sponsored a state-of-the-art review on prevention of oil pollution and mitigation of its effects. Areas for further research and development were identified. The National Academy of Sciences, under a Coast Guard sponsored study, developed a comprehensive hazard evaluation system for bulk cargoes, which was used by a joint industry-Coast Guard task group in drafting new regulations for barge transportation of bulk liquids and liquified gases.

The Intergovernmental Maritime Consultative Organization (IMCO) has held several recent meetings to discuss problems connected with transport of large quantities of oil, and in particular the reduction of hazards posed by the vessels. Safety of navigation, oil pollution, design of ships carrying noxious cargoes, and legal aspects have been considered. Amendments to the International Convention on Prevention of Pollution of the Seas by Oil and the Convention for the Safety of Life at Sea will be considered at IMCO meetings in the fall of 1968.

Channel and Harbor Research

The Corps of Engineers has primary responsibility for construction, maintenance, and protection of channels and harbors, and supports relevant research in such areas as water movement, shoaling, stability of breakwaters and jetties, silting of ship channels, harbor surges, wave causes and characteristics of ocean surface waves, wave refraction, propagation and effects of seismic waves, and acquisition of basic data on waves and currents and sediment movement.[9]

[9] There are now 500 commercial harbors with depths up to 45 feet, approximately 250 small-craft harbors, and 23,000 miles of inland and intra-coastal waterways.

The Corps has 56 coastal channel and harbor improvement projects currently underway, for which the total Federal costs are estimated to be $870 million.[10] Congress has authorized (but not funded) another 70 projects,[11] to cost an estimated $780 million.

Even with these planned improvements, however, many existing channels will not be adequate to accommodate the deeper-draft tankers and dry bulk vessels now operating. These newer vessels and further technological advances that can be expected will necessitate new or improved channel and harbor facilities. In some cases these can be effected by deeper dredging of existing channels. In others, however, dredging to greater depths is impractical. For example, substantial costs are associated with cutting through rock at fairly shallow depths. Also, dredging can result in salt-water intrusion or damage to fish and wildlife. The need for such dredging may be reduced by selective development of ports on a regional system basis, or by construction of off-shore terminal facilities.

New Initiatives

In view of the importance of maritime activities to the economy and to international leadership in marine science and technology, the Marine Sciences Council selected three areas for priority attention during FY 1969 and made specific recommendations concerning:

—development of a national plan for navigation;

—programs for preventing and ameliorating the effects of accidents involving oil and other hazardous substances;

—planning for a broad approach to port development and redevelopment.

1. *Navigational Aids and Other Supporting Research.* A national plan for navigation is being developed by the Department of Transportation (Coast Guard and Federal Aviation Agency). The plan will consider the development and operation of aids to navigation to serve the current and future needs of aviation and maritime commerce. Navigation satellites and advanced ground-based systems will be considered. The plan will identify areas of Federal responsibility for navigation services, and the technology—current and projected—to carry out these responsibilities. It will then specify

[10] Major individual projects are in New York Harbor, the Delaware River, the Mississippi River at the Gulf outlet, the Sacramento River, and connecting channels in the Great Lakes.

[11] Total includes several non-coastal projects on navigable rivers.

the systems to be operated by the Federal agencies, and indicate needed research and development efforts to meet future navigation service requirements. Charting needs will also be considered.

2. *Research and Action for Pollution Avoidance and Abatement.* The joint study of the Departments of Transportation and Interior on oil pollution has outlined a national program to deal with the hazards of oil spills from ocean-going transportation. The study recommendations encompass policies, procedures, and programs intended to prevent disasters from hazardous cargoes and to mitigate the damage ensuing if a disaster occurs.

Major regulatory proposals of the Joint Report include responsibility on the discharger for cleanup of spilled oil and other hazardous cargoes, and authority for the Federal Government to clean up if dischargers fail to do so, and to secure reimbursement of costs from dischargers.

The Joint Report also recommends U.S. efforts for strengthening international conventions and commitments: establishment and use of sea lanes; controls on discharges into United States-Canada boundary waters; and feasibility studies of shore guidance systems for ships carrying hazardous cargoes into harbor areas.

The planning, regulation, international negotiation, and enforcement actions needed to deal effectively with oil pollution from ocean transportation are based very substantially on science and technology.

Fundamental scientific questions requiring attention concern oil-water mixing, ways of absorbing oil, the microbiology of degrading oils, harmful effects on marine and shore life, and effective methods of cleaning beaches.

Applied research and development topics identified by the Joint Report as requiring attention include:

—techniques for improved containment control, treatment of spills, and recovery of pollutants;
—techniques for delivery of equipment to handle spills;
—techniques for protection and rescue of flora and fauna;
—detection, surveillance, and dispersal prediction techniques;
—oil-water separation;
—vessel design and construction principles;
—devices and equipment for shore protection and cleanup and for disposal of spill—materials collected.

The proposed research and development represents a long-term program. Lead times for some essential lines of inquiry extend to several years, which places special urgency on an early beginning.

Budget requests of the Departments of Transportation and Interior in FY 1969 of about $3.3 million [12] will permit initiating such projects.

[12] This is the sum of $1.5 million for the Department of Transportation and $1.8 million for the Department of the Interior. The latter amount is included as a part of "Water Quality Enhancement" under Development and Conservation of the Coastal Zone in Appendix A financial tables.

3. *Harbor and Port Development.* A multi-agency research effort has been initiated to study requirements of a national system of ports with particular attention to regional aspects. As a first step, preliminary planning and establishment of multi-agency working arrangements are being emphasized during FY 1968, and initial fact-finding is to be conducted in FY 1969 at a $100,000 level of effort by the Corps of Engineers. It should also yield requirements for engineering development which will contribute to port efficiency in the short run, as well as to the design of ports for the future. The The Department of Transportation and the Corps of Engineers have primary concern in this research program in its broadest aspects. The Maritime Administration will contribute technical engineering knowledge in cargo handling, shipping requirements, and related areas. Other Departments will participate in projecting shipping loads. The Department of Housing and Urban Development will consider relations betwen port development and urban expansion and redevelopment.

This multi-agency effort will include a study of port needs and the costs and impact of the kind of improvements that modern shipping technology indicates as potentially desirable.

As currently envisioned, the study will include analyses of trends in commodity movements and fleet composition, and implications by region of projected traffic movement and vessel size; requirements for port and related facilities to accommodate prospective traffic effectively; alternative technological means for accommodating future transport systems; and appropriate financial participation by non-Federal entities, including States and local subdivisions.

Port authorities and other State-local interests will be asked to participate in advisory capacities as well as to provide basic information.

"If this should be necessary, I know of apparatus for use at sea for attack and for defense." —LEONARDO DA VINCI

Chapter VII

STRENGTHENING MILITARY PROGRAMS FOR NATIONAL SECURITY

SINCE the strength of our Nation springs from many sources—economic, social, and scientific, as well as military—nearly every element of the marine science program supports national security. This chapter is concerned with programs unique to the needs of the Department of Defense. All military marine science programs are designed primarily to provide ocean-related scientific knowledge and engineering technology upon which to base policies, decisions, development, and operations for military security. Military efforts which make substantial contributions to other national needs and goals, and which must be described with them to give a coherent picture of applicable Federal effort, are set forth as an integral part of other chapters of this report.

Within the Department of Defense, the Navy has the primary responsibility to provide the sea-based forces to defend the United States. The sea-based forces provide a capability for:

—stategic deterrence by deployment of Polaris submarines;
—anti-submarine operations if freedom of the seas is threatened from below;
—support of amphibious operations, mine warfare, and limited ground action;
—surveillance of the oceans to detect and track potentially aggressive forces;
—operations to conduct and protect essential shipping.

To perform these roles, the Navy must expand knowledge and understanding of the sea and its characteristics; provide the ability to examine even the most remote depths of the sea; construct and improve ships, structures, and equipment which will perform in the marine environment; and transport men and material quickly wherever they are needed. In other words, the Navy seeks to have the capability and knowledge of the three-dimensional marine environment—to operate as needed anywhere, in any weather, and at any depth.

The present strength of the Navy is measured by quality as much as quantity—and, in this regard, the superior military characteristics of every class of ship reflects successful integration of modern science and technology. The Navy recognized this ingredient before World War II and developed thereafter a strong tie to the academic and industrial world both to communicate Navy interests and to extract the best technology the country offers. It is significant that well over half the Federal marine sciences program is currently sponsored by the Navy.

Knowledge gained from military programs is, to the extent permitted by security considerations, made available in unclassified form for general use. For example, the Navy's program in mapping, charting, and geodesy produces data and charts for geodetics and world-wide shipping activity. Its programs of ship design and materials development, the most comprehensive in the Nation, provide knowledge for private shipbuilding and Federal maritime agencies such as the Coast Guard, the Environmental Science Services Administration, and the Maritime Administration. Navy developments in navigation, which range from submerged acoustic position-keeping to locating position on the Earth's surface by means of satellites, have been released for scientific and commercial use. The programs of the Advanced Research Projects Agency, directed toward detection of submerged nuclear explosions in any part of the world, provide knowledge of the Earth's crust and energy transmission characteristics which specifically apply to earthquake studies and volcanology.

The Fiscal Year 1969 Budget

Funds proposed for the marine science components of the military programs for national security for FY 1969 amount to $150.1 million, about 34 percent of the total marine science budget.[1] This represents an 11 percent

[1] All Navy programs are required for national security, but those that have nonmilitary uses as well are classified in the tables under other headings such as Research and Mapping, Charting, and Geodesy to show the total Federal effort.

increase over FY 1968, reflecting primarily increased support of fleet operations and priority developments in military ocean engineering. Program elements and funds proposed are:

—surveying the properties of the ocean and ocean bottom, Navy ---------- $29.4 M
—marine science and technology in support of weapon systems, Navy ---------- 37.7 M
—development of undersea search, rescue, recovery, and man-in-the-sea capability. (Deep Submergence Systems Project and closely related efforts) Navy---------- 81.5 M
—test and calibration facility for instrumentation, Navy----- 1.3 M
—marine science in support of safeguards for limited test ban treaties (VELA-UNIFORM program), Advanced Research Projects Agency---------- 0.2 M

Surveys for Defense Systems

The purpose of these surveys is to obtain comprehensive oceanographic and acoustical information about ocean areas of the world in which our naval forces may operate. The surveys provide both fleet support and essential environmental data for design of future systems. Aided by the Coast Guard, private contractors, and ships of opportunity, and benefitting from the recent commissioning of two modern, automated survey ships of its own, the Navy is making substantial progress toward coverage of the areas of highest priority. In FY 1967, for example, the Navy collected:

—over 100,000 miles of seismic sub-bottom profiles and ship-towed magnetic data;
—860 Nansen casts for submerged water analysis;
—hundreds of bottom photographs, geological cores, biological and radiological samples, and current measurements; and
—many thousands of measurements of propagation of acoustic energy over a wide spectrum of frequencies.

While the above oceanographic surveys are intended for military use, others which are closely allied to them are available for civilian use. These include the mapping, charting, and geodetic efforts which are set forth in Chapter VIII. These latter surveys resulted in shipboard collections of approximately a quarter-million track miles of precise bathymetric, magnetic, and gravity data, and the airborne collection of an additional one-quarter of a million miles of geo-magnetic data.

The USNS Silas Bent became fully operational in FY 1967 and was joined by her sister ship, the Elisha Kane, in FY 1968. In addition to being the first Navy oceanographic survey ships to have highly automated data processing equipment on board, they have greatly improved sensors, winches, and handling gear.

Marine Science and Technology

Marine science and technology in support of specific weapon systems is budgeted at $37.7 million for FY 1969. Most of this money will support studies of the characteristics and behavior of sound energy in the ocean. The primary objective is to advance the Navy capability to detect, identify, seek, and destroy hostile submarine forces, but the knowledge gained serves the converse purpose of helping to conceal Polaris submarines and, thus, preserving the invulnerability of the Fleet Ballistic Missile System. Certain of these studies can only be carried out satisfactorily in instrumented and controlled open-sea laboratories, such as the recently commissioned Atlantic Undersea Test and Evaluation Center (AUTEC) and the Ocean Engineering Range at San Clemente Island off California.

As part of this program, the Navy has developed the capability for rapid processing, storage, and retrieval of data on ocean conditions for anti-submarine warfare (ASW) applications. These data also have immediate operational applications as a part of the Navy environmental prediction services, described in Chapter VIII. Combining these data with improved mathematical models of the ocean and atmosphere, it is now possible to produce routine analyses and forecasts of important oceanographic parameters (e.g., ocean temperatures and surface wave conditions), for large ocean areas. It is also possible to provide more detailed spot analyses for special areas upon request from fleet units in the area. Temperature and sound velocity versus depth and geographical location are routinely predicted for the northern hemisphere oceans, and many thousands of special acoustic propagation predictions are provided for ASW purposes. To the extent possible, this information is made available in unclassified form for fisheries, shipping, and other non-defense use. For example, the Departments of the Interior and Navy have executed an exchange agreement to study the use of advanced acoustic technology in the location of marine animals and the prediction of the distribution of marketable fish, as well as acoustic false targets of military importance.

Undersea Search, Rescue, Recovery, and Man-in-the-Sea

This program of advanced ocean technology is intended to improve the Navy's deep ocean operational capability for rescue, search, salvage, exploration, and diving operations. This need, first highlighted by the loss of the THRESHER in 1963, was required for search and salvage by the Navy in 21 operations in 1967, primarily for aircraft.

For FY 1969, $81.5 million are proposed primarily for the Deep Submergence Systems Project (DSSP), with specific mission requirements for:

—submarine location, escape, and rescue;
—object location and small object recovery;
—large object salvage;
—"man-in-the-sea";
—the nuclear powered, deep-ocean research and engineering vehicle-NR–1.

The Submarine Location, Escape, and Rescue Program will develop the capability for:

—ships to locate a submerged, disabled submarine;
—personnel escape from disabled submarines at depths to 600 feet;
—rescue parties to extricate personnel from sunken submarines in any weather, using Deep Submergence Rescue Vehicles (DSRV), small submarines, which can either be transported by air or carried submerged on the deck of a "mother" submarine.

A contract for the first DSRV was let in FY 1966, and for the second in FY 1968. The first unit is expected to become operational in 1970. The long-range plan calls for world-wide capability with three rescue units consisting of two DSRV's and one surface support ship (ASR). This full rescue force, including modifications to the units of the submarine force, is scheduled to be available by 1975. A contract for the first two Catamaran-type ASR's was placed in August 1967, using shipbuilding funds from FY 1967 and 1968. (See Figure VII.1.)

The Small Object Location and Recovery Project will enable the Navy to locate and recover small objects at depths down to 20,000 feet in conjunction with the overall salvage mission of the Navy. The Deep Submergence Search Vehicles (DSSV), unmanned search and recovery devices, and support ships will not be completed before 1974. Development of advanced sensors and power plants, and design of the DSSV will commence in 1968; programs leading to construction of the first DSSV will commence in 1969.

The Large Object Salvage System Project will provide a system capable of recovering large objects, including intact submarine hulls, from depths

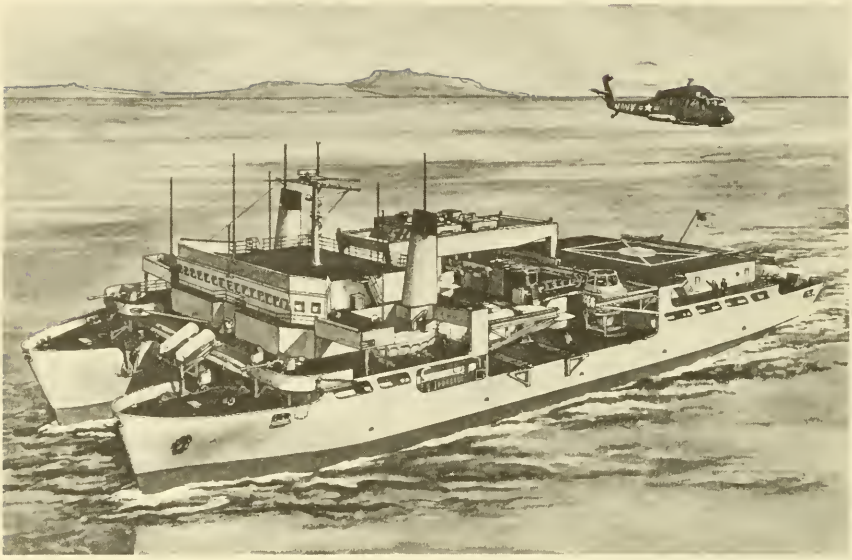

Figure VII.1. *Essential to the Submarine Search and Rescue System is the Auxiliary Submarine Rescue (ASR) vessel, shown here in prototype. The system will consist of three rescue units, each including one ASR and two Deep Submergence Rescue Vessels (DSRV). The first unit will become operational in 1970. Three units will comprise (with necessary submarine modifications) a world-wide rescue capability. (U.S. Navy photo.)*

down to 850 feet. Two salvage units are scheduled for completion in 1974. Each consists of a Salvage Operational Control Ship, and two lift ships, plus associated equipment. The system anticipates use of human divers to aid in salvage operations. The prototype MARK II Deep Dive System, which includes a Deck Decompression Chamber (DDC) and a Personnel Transfer Capsule (PTC) is under construction at Mare Island Naval Shipyard; it should be completed in time for the SEALAB III experiment this summer. (See Figure VII.2.) Planned activity for FY 1969 includes awarding a contract for a second MARK II Deep Diver System (a DDC and a PTC) plus development of tools and aids for divers.

The Man-in-the-Sea Project, closely tied to Large Object Salvage System, will extend man's capacity to live and perform useful work to greater depths—850 feet by 1972. Two open sea experiments of long-duration bottom living have been conducted (up to 45 days). A third, SEALAB III, is planned for a depth of 600 feet (with excursions to 750 feet) in the summer of 1968.

Both private industry and the Navy are developing the equipment and technique by which divers can work in the sea longer, at greater depths, with better tools and more safety. The goals of accomplishing useful work by

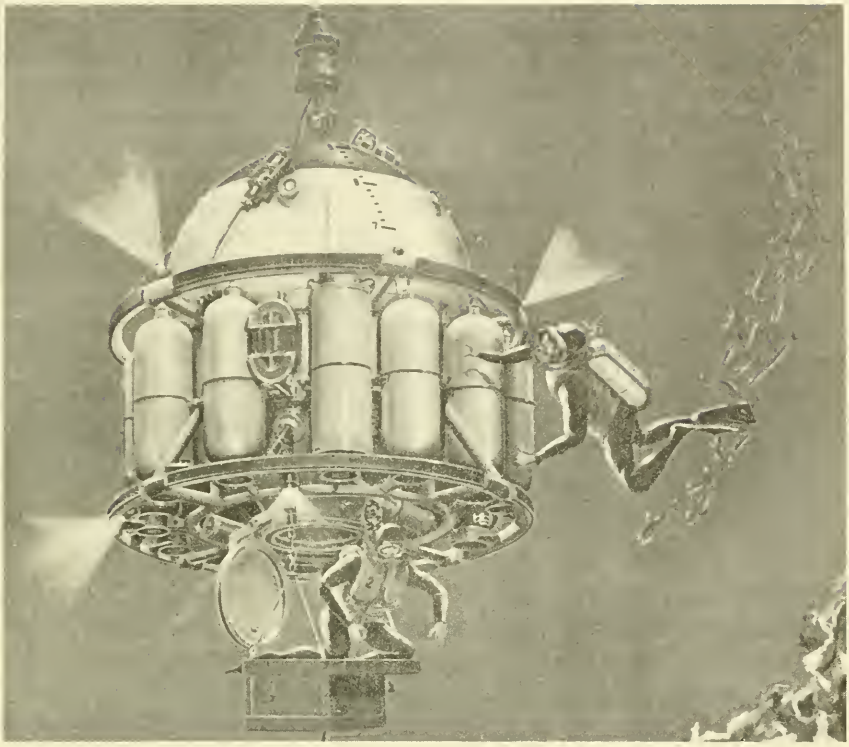

Figure VII.2. *The Personnel Transfer Chamber (PTC), an elevator-like diving station for saturated divers, provides transportation between the ocean surface and the ocean bottom. The PTC is being developed by the U.S. Navy in support of a new system for the salvage of large objects to depths of 850 feet. It is expected that the system will be capable of raising objects, including sunken aircraft and disabled ships, weighing up to 1,000 tons deadweight. The PTC and its related equipment are being used this year in support of Man-in-the-Sea experiments in the SEALAB III series. (U.S. Navy photograph.)*

increasing diver capability, communications, and visibility at 600 feet—then 850 feet and eventually at least 1,000 feet—were brought nearer during the past year by such developments as:

—commencing construction of the prototype Navy MARK II Deep Dive System, designed for 850 feet;

—developing a carbon dioxide absorbent device with ten times the capacity of existing equipment;

—developing a new microphone for divers that is unaffected by pressure at 600 feet and a micro-miniaturized sonar with high resolution that mounts on a diver's "helmet" and helps him "see" in murky water.

In FY 1969, the SEALAB III results will be evaluated and development of aquanaut equipment will continue. This man-in-the-sea capability should have commercial application as oil, gas, and mineral extraction move into deeper water on the Shelf and operations are conducted submerged.

The Deep Ocean Engineering Vehicle Project will provide a research submersible (NR–1) which combines the long endurance of a nuclear power plant with the control and instrumentation developed for the DSRV rescue submersible. This submersible will also provide the technical basis for future development of nuclear-powered, oceanographic research submersibles to operate at even greater range and depth. Congress authorized the construction of NR–1 in the FY 1965 shipbuilding program. It is under construction at Groton, Connecticut, and should be commissioned in 1968.

Complementing this program for Undersea Search, Rescue, Recovery, and Man-in-the-Sea is a Deep Submergence Biomedical Program to improve decompression schedules for deep diving, diver nutrition, and study of physiological and psychological factors affecting divers. A swimmer-support program is closely integrated with the above efforts.

Construction of Oceanographic Ships

The Navy oceanographic fleet (including ships being used by private institutions) consists of 15 research and 16 survey ships. Thirteen new ships have been authorized in previous years and are under construction, including building contracts awarded in FY 1967 and early FY 1968 for:

—Two new AGOR–14 class research ships which incorporate cycloidal propellers for use by Woods Hole Oceanographic Institution and Scripps Institution of Oceanography and two others of the same class for use by Navy laboratories;

—two new catamaran Submarine Rescue Vehicles (ASR's) which combine the support capabilities for the new rescue submersibles and for operating the Navy's advanced diving systems. (Because these ships have a much broader utilization potential than support of rescue submersibles and divers, the cost of the first prototype ship was included in the marine sciences program.);

—one medium oceanographic and one coastal hydrographic survey ship to replace the aging USNS MAURY and USNS TANNER;

—two improved ALVIN-type submersibles with operating depths of 6,500 feet.

A contract for a catamaran-design AGOR is scheduled to be let later in FY 1968, but no starts are funded in the FY 1969 budget. The ship construction program is summarized in Table VII.1.

Table VII.1—Ships for Navy Oceanographic Program

Program	FY 1968 status operational ships		Ship construction program
	New construction	Conversions	Under construction
OCEANOGRAPHIC RESEARCH SHIPS:			
Navy Laboratories	4	1	4
Institutions	3	7	3
SUB-TOTAL	15		7
SURVEYING SHIPS:			
Oceanographic	2	2	1
Mapping, Charting & Geodesy	---	12	5
SUB-TOTAL	16		6
GRAND TOTAL	31		13

Project VELA-UNIFORM

To improve our ability to detect, locate and identify underground and underwater nuclear explosions, the Advanced Research Projects Agency (ARPA) has for a number of years conducted a program called VELA-UNIFORM. Some of ARPA's significant marine science efforts during FY 1967 and 1968 included:

—seismic refraction measurements in the Aleutian Island region to investigate velocity anomalies in the earth's crust and upper mantle;

—an ocean bottom seismograph experiment in international waters off the Kurile Islands to study propagation characteristics of seismic waves from earthquakes;

—deployment and recovery of 27 untethered 30-day ocean-bottom seismic recording units (ten are located in water more than 15,000 feet deep). A system design was developed for an untethered ocean-bottom seismograph (enclosed in a glass-pressure vessel) capable of 120-day continuous recording in water as deep as 30,000 feet;

—an unmanned, ocean-bottom geophysical station at a depth of 12,600 feet. The station is located 80 miles off the coast of California and is linked by cable to the mainland. It is the first seismograph installation to provide continuous records from the ocean floor.

In FY 1969, ARPA intends to complete the field testing of a 250-ton capacity, towed vehicle designed for the safe handling of large charges at sea.

New Facilities

The Atlantic Underwater Test and Evaluation Center (AUTEC), in the Bahamas, was commissioned in 1967 and will be completely operational in 1970. The FLIP, a stable, acoustic platform which can extend 250 feet below the surface, was modified to improve laboratory and living space. A pressure vessel ten feet long and six feet in diameter for use at 5500 p.s.i. was commissioned at the Naval Civil Engineering Laboratory, and a new laboratory for research on structures was put in operation at the Ship Research and Development Center at Carderock, Maryland.

Facilities scheduled to become operational in FY 1969 include the Ocean Engineering Facility at San Clemente Island, California, which provides an ocean environment test range with wide capabilities for use by both government and non-government engineers, and the deep ocean pressure testing complex at the Navy Ship Research and Development Center, Annapolis, Maryland. The FY 1969 program also includes funds for a deep ocean engineering simulator at the Mine Defense Laboratory, Panama City, Florida.

The Future

Our Nation's goal is lasting peace, and we seek it by every means, including a strong Navy. A strong Navy reduces the danger of armed conflict, links us with our allies, deters potential adversaries, and strengthens our ability to contain limited conflicts. Assured lifelines of seaborne traffic are essential to the military and economic strength of the U.S. and our allies. We have no monopoly, however, on naval forces or technology. Our present advantage in nuclear propulsion and underwater technology is a key to maintaining superiority in naval strength, by quality as much as by numbers. Technology

also provides wider options to meet future contingencies at appropriate levels of response. The roots of naval technology must be continuously reexamined, existing systems refined, and new concepts developed in order to maintain our sea-based defense forces essential for national security.

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"Aside from its importance to many branches of science, a knowledge of the oceans has a practical value for mankind. The intelligent development of our fishing industries, the laying of ocean cables, the proper construction of harbor works, oceanic commerce and navigation, as well as long range weather forecasting, are all dependent on our understanding of oceanic conditions." —THE LAST CRUISE OF THE CARNEGIE, 1928–1929

Chapter VIII

UNDERSTANDING AND SURVEYING THE OCEAN ENVIRONMENT

If use of the ocean's resources is to increase significantly in this century, in the recovery of major fishery and mineral resources, for example, and if knowledge is to be gained to enable accurate forecasts of such weather phenomena as droughts, floods, storms, and hurricanes, then greater effort must be made to explore, measure and map the seas.

We include within this chapter two different sets of observations of the marine environment: those that lead to maps and data files, and those needed for prediction of environmental variables that change rapidly with time.

As to environmental predictions, better knowledge of air-sea interaction processes should lead to more precise and longer range forecasts of weather and storms, waves, ice, tsunamis,[1] tides, coastal surf and currents, storm surges, and ocean temperatures. These will:

—benefit national defense and expanding marine industrial activities;
—reduce the destruction of life and property in the Coastal Zone;
—lead to improvements in design and safety of coastal and off-shore facilities, including harbors, sea walls, breakwaters, and oil drilling platforms;
—enhance industrial, commercial, agricultural, and other land activities, such as building construction, air and sea transportation, and recreation, that are directly affected by weather and coastal oceanic conditions;

[1] Seismic sea waves.

—facilitate better planning of water conservation measures for crops and management of municipal water supplies;
—improve flood warnings to allow advance application of necessary control measures;
—improve routing services for maritime shipping to avoid hazardous seas and storms, minimize cargo damage, and economize on operational costs;
—increase the operational efficiency of U.S. commercial fisheries.

The identification and assessment of ocean resources and features through systematic exploration will:

—aid transportation and commerce, and foster safe navigation;
—encourage development of fuel and mineral supplies off-shore;
—improve effectiveness of our commercial fisheries;
—provide basic knowledge for consideration of international legal questions related to ocean resources;
—aid in establishing Federal-State development and regulatory policies.

Both environmental observations and exploration should contribute answers to major questions of science.

Today, nearly all scientific observations of the seas are made by ships; and ships, complemented by submersibles, will continue to be primary vehicles for geographical exploration of ocean resources and deep sea features. But as spacecraft and buoys are deployed, their measurements will complement ship observations, especially in investigations of the dynamic properties of the seas that change rapidly and are required for environmental prediction. Ocean exploration is thus expected not only to increase in momentum but also to change in technological content and breadth.

Ocean Observations and Predictions

About five percent of the Federal effort in marine sciences is devoted to observations related to understanding and predicting the ocean environment, largely dealing with time-dependent variables. The Navy, Environmental Science Services Administration (ESSA), Coast Guard, National Aeronautics and Space Administration (NASA), and Atomic Energy Commission (AEC) fund these activities as shown in Table VIII.1.

A broad range of marine forecasting services for defense forces has been developed by the Navy in response to world-wide national security requirements. These include:

—sea surface and water column temperature, salinity, and sound velocity prediction for antisubmarine warfare;

—sea ice observation and forecasting for fleet operations and seaborne logistics;

—sea state prediction for fleet operations and spacecraft recovery at sea and for Coast Guard activities on the Great Lakes;

—nearshore environmental prediction, including beach breaker and surf forecasts, for mine warfare and amphibious operations;

—high seas and coastal marine weather forecasts to support fleet operations.

Table VIII. 1—Funding for Ocean Observation and Prediction

(In millions of dollars)

Agency	Estimated, FY 1968	President's Budget, FY 1969
Department of Defense:		
Navy	10.4	11.0*
Army	0.3	0.3
Department of Commerce:		
ESSA	6.1	6.3*
Department of Transportation:		
Coast Guard	5.5	6.8
National Aeronautics and Space Administration	1.3*	1.3*
Atomic Energy Commission	.9	.8
Total	24.5	26.5

*ESSA budgets an additional $8.2 million to support upper air sounding programs, hurricane reconnaissance research, and operational satellite programs that also contribute to goals described in this Chapter. Navy budgets an additional $8.9 million for similar efforts not reported as part of the Marine Sciences Program. In addition, NASA is funding $5.3 million and $10.2 million in FY 1968 and FY 1969, respectively, for remote sensor surveying aircraft that may acquire oceanographic data. Further, NASA is funding approximately $2 million in FY 1968 and FY 1969 for remote sensor research and development. These studies are designed to lead to research and development of the Earth Resources Survey Program which includes the Earth Resources Technology Satellite (ERTS).

For civilian use, environmental prediction services operated by ESSA include:

—high seas, coastal, and Great Lakes marine weather forecasts;

—tropical storm, hurricane, and storm surge warnings and forecasts;

—tide and tidal current predictions;
—breaker and surf forecasts for the beaches of southern California;
—tsunami warnings.

ESSA is establishing an estuarine flushing and non-tidal prediction service which provides monthly advisory bulletins on variations in renewal rates for the rivers and harbors of large urban communities, with initial efforts in the Penobscot Bay area in New England. The service is intended for use by municipal and port authorities, water and sanitation departments, Federal Water Pollution Control Administration, Atomic Energy Commission, Public Health Service, and Fish and Wildlife Service. It will assist agencies in industrial effluent discharge control, industrial and potable water intake regulation, determination of sewage and industrial waste treatment requirements, recreation planning, and protection of public health and fisheries.

An advanced forecasting model simulating the effects of exchange of heat and momentum between the oceans and atmosphere is now employed at the ESSA National Meteorological Center. This has resulted in improvement in forty-eight hour forecasts of continental and marine weather conditions.

Diverse ocean observation and prediction programs in polar, subpolar, and other regions are supported by the Coast Guard, employing ships, aircraft, towers, and buoys. Ships and aircraft of the International Ice Patrol and ice breakers make ice and ocean current observations for the protection of North Atlantic shipping. Ships enroute to and from ocean stations and on station make physical measurements to monitor the changing nature of major ocean currents. Ships from a number of agencies also participate in international studies, such as the cooperative study of the Kuroshio current and the oceanographic and fisheries investigation of the Eastern Tropical Pacific.

NASA, as part of its Earth Resources Survey Program, supports a spacecraft oceanography project to assess and develop the application of space research and technology to marine sciences. During 1967, two NASA aircraft equipped with radiometers, scatterometers, spectrometers and cameras flew 14 missions to determine the response and effectiveness of these instruments in remotely sensing sea ice, land-water boundaries, sea state, schooling fish, fresh-salt water interfaces, and sedimentation patterns. Thermal contrasts at the boundaries of several major ocean currents were identified by high resolution infrared radiometry in the NIMBUS spacecraft. Video photographs of the Pacific Ocean obtained by Applications Technology Satellite 1 illustrated the relationship between cloud patterns and major ocean currents and upwelling zones characteristic of high fisheries production. (See Figure VIII.1).

The Atomic Energy Commission supports a program directed toward developing accurate prediction models for assessing the potential hazards of long-period water waves that might result from large yield detonations

at or near the ocean surface. It is expected that major goals in the program will be achieved in FY 1969 and that funding can thus be reduced in FY 1970 and beyond.

Figure VIII.1. *A corner of East Africa and the Arabian Peninsula looked like this to Astronauts Conrad and Gordon during the GEMINI XI flight on September 14, 1966. This is the season when the water level of the Red Sea (left) recovers from the great loss by evaporation during the summer months. The warm (32 degrees Centigrade), highly saline (39–40 parts per thousand) waters begin to pour into the western Gulf of Aden. As the Red Sea water is denser than that of the surface layers, the new water sinks to a depth of about 200 meters. The eddy system outlined in the photo above (right center) is the surface flow and turbulence caused by this displacement. Such current systems may contain significant concentrations of fish. (Photograph by NASA; analysis by Bureau of Commercial Fisheries.)*

Mapping, Charting, and Geodesy

In this section, those features of the oceans are dealt with which vary slowly with time so as to permit preparation of maps. Just as maps have been indispensable in the development of our land resources, maps are also the foundation for understanding and use of the oceans. Yet the oceans are largely unexplored beyond the gross shape and structure of the sea floor, and maps for science, economic development, and national defense are often inadequate. Needs are multiplying for a wide variety of maps—of biological stocks, mineral resources, and physical and geophysical characteristics of the sea and seabed.

Mapping requires accurate navigation and geodetic control. In recent years, successful development of electronic aids, especially several series of Loran systems, has led to greater precision in positioning. The Transit navigational satellite system discussed in Chapter VI has been released for civilian use and will provide more precise control for oceanwide surveys.

Current Exploration

Mapping, charting, and geodesy account for roughly 18 percent of the marine science funding as shown in Table VIII.2. Over 30 ships in the Federal oceanographic fleet are engaged in ocean surveying activities. The cost of operating these ships in FY 1968 totaled $34.4 million; this represents about 37 percent of the ocean exploration budget. Several agencies conduct mission-oriented oceanographic surveys, but the Navy and ESSA support most of this effort and provide most of the widely used general purpose maps and charts.

Table VIII.2—Ocean Exploration—Mapping, Charting, and Geodesy

(In millions of dollars)

Agency	Estimated, FY 1968	President's Budget, FY 1969
Department of Defense	56.2	72.3
Department of Commerce	18.0	19.5
NASA	.3	.3
Total	74.5	92.1

Recent ocean surveys have mapped:

—bathymetric and geophysical characteristics of 1,500,000 square miles of the North Central Pacific between the Hawaiian and Aleutian Islands as part of the SEAMAP program (ESSA);

—precise bathymetric, geophysical, and oceanographic data over 260,000 track miles (Navy);

—the hydrography and currents of coastal and riverine areas of South Vietnam (Navy);

—seasonal physical, chemical and biological productivity factors of the Eastern Tropical Pacific (Bureau of Commercial Fisheries, Coast Guard, Navy, ESSA);

—geophysical and acoustical properties of over 7,000,000 square miles of ocean areas (Navy);

—geological and geophysical characteristics of the U.S. continental Shelf and Slope (Geological Survey);

—the geomagnetic field in many parts of the world by aircraft (Navy);

—the hydrography of all coastal waters of the United States and Alaska and estuarine circulation patterns of critical harbors (ESSA); and

—navigational hazards in the Great Lakes (Corps of Engineers).

New Emphasis on Technological Developments

The magnitude of the task of observing and mapping such a large fraction of the Earth's surface by conventional surface ships has motivated applications of modern technology—both to increase efficiency of measurements from shipboard and to supplant or supplement ships as sensor platforms. For example, the Navy is developing a high-speed coastal charting system. New emphasis also is being placed this year on potential use of spacecraft and buoys and the balanced combination of systems utilizing all techniques.

Ocean buoys are effective in making many kinds of ocean observations. A recent study, funded jointly by Federal agencies, concluded that systems of data buoys with wide geographical coverage are technically feasible and the most cost-effective means of satisfying a large number of government-wide operational and research requirements for marine meteorological and oceanographic data. The study analyzed and categorized four sets of requirements for marine data:

a. global (deep ocean, large scale—300 to 500 mile grid);

b. coastal North America (within 400 miles of North America, medium scale—50 to 200 mile grid);

c. Great Lakes and estuaries (territorial U.S. waters, small scale—10 to 50 mile grid);
d. research requirements (all areas, various scales from large to very small scale grid).

The study showed that a substantial saving is possible if buoy systems are designed and operated to serve the national requirements for data acquisition as opposed to single agency requirements.

The Marine Sciences Council reviewed this study and concluded that a National Data Buoy System had sufficient promise to warrant initial development of prototypes. The Coast Guard was assigned lead-agency responsibility for further research, development, testing and evaluation to advance data buoy technology, and to develop and evaluate system requirements and capability preparatory to a future decision to establish a National Data Buoy System.

The Department of Transportation is requesting $5 million for these programs in FY 1969. An additional $250,000 is being reprogrammed for further study of technical approaches and plans in FY 1968.

The possibility of observing important characteristics of the oceans from high-flying aircraft and spacecraft has been investigated by Federal agencies and other organizations for a number of years. Several experimental areas appear especially promising:[2]

—sea-state and sea level measurement;
—thermal measurements of the sea surface;
—location and "mapping" of surface ocean currents;
—sea ice measurement and location and classification of icebergs;
—river discharge and delta studies;
—delineation of shorelines, shoals and sea bottom contours, and elimination of "doubtful shoals" in the high seas;
—detection and measurements of biota;
—sea slope measurements;
—observation of air-sea interaction phenomena;
—detection of upwelling zones.

The Marine Sciences Council supported a contract study to evaluate the future potential of satellites for ocean observations. The study report, which will soon be released, projects the technological state-of-the-art for observations of sea surface temperature, sea ice, and wave height for the next five years, analyzes requirements and related costs, and describes benefits that could be achieved.

In October 1967, the Council issued a report, *United States Activities in Spacecraft Oceanography,* prepared by NASA and the Naval Oceanographic Office, assisted by other interested agencies. This report presented new information about the potential of satellite observation to assist scientists and

[2] Funds for these developments are reported in Table A–1 of the Appendix under "General Purpose Ocean Engineering."

engineers in planning for possible participation in future programs.

Inherent in the advancement of space oceanography capabilities to benefit many agencies is the need for closer coordination of related programs. The Council accordingly recommended that NASA assume lead agency responsibility for coordination of sensor technology, techniques for space oceanography and testing of new developments.

It also endorsed FY 1969 initiatives by (a) ESSA, to employ an advanced camera system and high resolution scanning radiometer, piggyback, in the TIROS M and advanced TIROS operational satellites for mapping sea and lake ice and surface temperatures, locating major currents, and estimating the state of the sea; and (b) the Bureau of Commercial Fisheries, to expand studies of the usefulness of satellite radiometric data and photographs in locating high density fisheries.

Planning Ahead

The need for intensified ocean exploration has been highlighted by deliberations of the General Assembly of the United Nations on questions related to jurisdiction over the deep ocean floor and its resources. A broad base of understanding about the oceans and their resources can contribute to informed judgments on legal issues of both national and international importance.

A comprehensive national program for ocean exploration was recommended in 1959 by the National Academy of Sciences' Committee on Oceanography. The Committee called for ocean-wide surveys: "Not only for research, but in order to exploit and use the oceans, we need detailed knowledge which can be obtained only through systematic surveys in three dimensions. . . It is essential that these surveys be conducted on an ocean-wide, ocean-deep basis as quickly as possible. Our knowledge is now limited largely to waters 100 miles from shore and even here is inadequate for present and future needs." The recommendation was reinforced by the Committee's 1966 report which urged that "the program be carried out in a systematic and expeditious manner."

As yet, only a limited program of ocean-wide mapping has been incorporated in agency plans. Moreover, despite cooperative exchanges of data and of scientists between agencies, Government-wide planning for ocean exploration and mapping and ocean observation and prediction on a continuous basis has not been achieved.

The Marine Sciences Council is beginning to remedy this deficiency.

Recognizing the need for long-range planning to implement Federal agency missions in these areas and to support policies and objectives of the

marine sciences legislation, the Council assigned to its Committee on Ocean Exploration and Environmental Services responsibility to begin to develop comprehensive Federal plans in 1968. To supplement agency staffs, both for planning purposes and for the United States' portion of international exploration, a small staff will be funded initially by the Marine Sciences Council.

Planning will consider both environmental prediction and exploration. National needs will be considered for observation and prediction services related to marine weather, sea state, tides and currents, including estuarine and coastal effects, state of the upper water column and thermocline, migration of principal current boundaries, tsunamis, and sea and lake ice. The plan will consider ways to fulfill these needs by defining goals, milestones, priorities, supporting air-sea interaction studies, technical facilities, and instrumentation, and the optimum combination of oceanographic ships, ocean buoys, aircraft, and spacecraft required in a national effort.

The special role of ships of opportunity will be considered. Over 2,000 merchant ships, American and foreign, including over 900 United States flag ships, and over 800 United States Navy ships, make certain kinds of marine meteorological and oceanographic observations. Limited biological observations have also been made by ships of opporunity. The plan will consider obtaining more complete data from a selected number of these ships to complement data obtained from other sources.

The kinds of projects being considered for the program are:

—delineation of the migration and movement patterns of major commercial fish stocks;

—fishery exploration in currently unexploited areas;

—acquisition of data relating fish distribution to environmental factors as a basis for providing fishery prediction services;

—preparation of small-scale topographic, geological, magnetic, and gravity maps of the Continental shelf and slope to identify potential mineral and fuel resource areas;

—preparation of geophysical and topographic maps of selected areas of the deep ocean floor;

—coring and drilling surveys of the continental margin and deep ocean floor in selected areas;

—facilitating data exchanges (following the objectives outlined in Chapter IX);

—determination of the origin and dynamics of ocean current systems;

—investigations of heat exchange and transport, air-sea interaction, and air mass modification;

—studies of storm genesis, propagation, and waves.

Planning will be accomplished in close consultation with the National Academies of Science and of Engineering, and other scientific and industrial

interests so as to complement and reinforce private research and engineering in the marine environment in the seventies.

Planning for ocean exploration will include programs for United States participation in international ocean exploration activities discussed in Chapter II. Through this international effort, nations can join in cooperative studies of the seas and their resources, with the derived knowledge shared fully among them. A technically sound program should attract broad participation within a framework of world-ocean surveys, regional surveys, and related problem-oriented research studies. Only a few nations have sufficient technical resources to conduct ocean-wide surveys, but many nations could participate in regional or local projects utilizing surveying technologies developed in other sectors of the program.

"When you can measure what you are speaking about, and express it in numbers, you know something about it." —LORD KELVIN

Chapter IX

INFORMATION MANAGEMENT

ADVANCES in marine science and technology depend critically upon the effective flow of information—from data collectors to data consumers. If we are to understand the complex nature of the marine environment and if understanding is to foster achievement of practical objectives, information must both be generated and made available to meet a wide variety of user needs.

Previously, oceanographic data were collected primarily by the same scientists and engineers who used the data. Now, with broader ocean-related activities and with data acquisition more complex and costly, the data commodity must be shared among a larger number of participants. More efficient recording, archival, processing and distribution systems are needed to provide information services not only for the oceanographic community, but beyond it to a larger community of state and industrial users, and public and private interests concerned with maritime policy, economic development, and legal principles for effective use of the sea.

Apart from the increases in size and complexity of the data community, increases in data traffic and changes in the character of data impose new problems in data management. The advent of synoptic measurement systems and the evolution of requirements to monitor the marine environment sharply increase the sheer quantity of information to handle. As the entire marine science enterprise has grown, increasingly careful consideration has been given to means to minimize cost and possible waste of human resources.

The complexity of data management can be illustrated by the variety of observable quantities and the diversity of their sources and end-uses.

Data are obtained from the world oceans, coastal waters, estuaries, and Great Lakes by:

—research and survey ships, off-shore platforms, submersibles, and divers;

—ships of opportunity in the merchant marine, Navy, Coast Guard and commercial fisheries;

—spacecraft, aircraft, and buoys.

Data may be real-time or archival; may be presented in the form of maps, documents, visual displays, analogue or digital records; and may consist of sea water, biological or geological samples.

Data involve more than 100 kinds of physical, geophysical, and chemical variables. Thousands of geological samples must be stored; more than one-half million species of biota must be classified; and great quantities of marine meteorological data must be processed.

In turn, data are used by:

—marine scientists and teachers;

—meteorologists and seismologists;

—naval planners and operators;

—commercial fishermen;

—producers of off-shore oil, gas, and minerals;

—regulatory authorities concerned with off-shore activities and environmental quality of the Coastal Zone.

Beginning some eight years ago, several Federal data centers were established to meet the demand for management of oceanographic data. These centers involve complex inter-connected functions of acquisition, standardization and tests for accuracy, storage, retrieval, analysis, and synthesis that must be performed to make data readily and economically accessible to specialized users.

The newly established data facilities almost immediately became inadequate as the result of insufficient national data bases, incompatible data formats for efficient exchange, delays in filing, archaic processing and communication methods, and lack of critical evaluation. An increasingly serious problem for the future is how to manage an even larger volume and diversity of marine data which are certain to result from intensified activities and new technologies. Data generation will increase rapidly with the expanding deployment of ocean buoys, modern ships with integrated sensors, spacecraft, and ships of opportunity. Effective data services that afford prompt and reliable dissemination should be developed to match the speed and sophistication of data acquisition if the benefits of new technology are to be

realized. Such services must be planned not only for the present but for the next ten years.

Recognizing that data management support is deficient, the Marine Sciences Council initiated in 1967 a major contract study on marine information problems. While final results of the study will not be available until early 1969, preliminary findings suggest steps necessary to improve existing marine data centers, and some corrective measures are being taken now.

Data Center Operations

Four marine data centers are currently operated by the Federal Government. The proposed FY 1969 budgets for these centers are shown in Table IX.1.

Table IX.1—FY 1969 Data Center Budgets

Activity	FY 1968	FY 1969
National Oceanographic Data Center	$1, 495, 800	$1, 778, 260
National Weather Records Center	*100, 000	*130, 000
Great Lakes Data Center	164, 000	167, 000
Smithsonian Oceanographic Sorting Center	192, 000	272, 000
TOTAL	1, 951, 800	2, 347, 260

*Supplemented by funds transferred from other agencies for reimbursable projects: FY 1968, $977,000; FY 1969, $1,165,000.

National Oceanographic Data Center

The National Oceanographic Data Center (NODC), located in Washington, D.C., was established by the Navy in 1960 and has been supported by multi-agency funding since that time. It provides oceanographic data from both foreign and domestic sources to United States and foreign organizations and institutions concerned with marine science and technology and ocean-related affairs. The Center receives, compiles, processes,and preserves oceanographic data; establishes procedures for insuring the accuracy and general quality of the data; prepares data summaries and tabulations; prepares and makes available indices of its holdings and other information necessary for requesting data or services; and performs data processing services at cost.

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Some specific accomplishments during FY 1967 were:

—Information requests involving less than one day of effort and handled without charge increased from 1260 to 1603 from the following sources: Educational and Research Institutions (19%); Foreign (4%); General Public (34%); Government Agencies (21%); and Industry (22%).

—Information requests requiring more effort and handled on a reimburseable basis increased from 85 to 127.

—Processing costs were decreased from $2.60 to $0.50 for a data unit of one thousand cards.

—Marine science data were acquired from 65 Federal and non-Federal organizations and from 31 foreign countries, increasing the size of holdings to the levels shown in Table IX.2, as of July 1, 1967. The table also shows the high concentration of physical data.

Table IX.2—NODC Data File

	Observations
Bathythermograph Data:	
Digitized	515, 000
Analogue	800, 000
Oceanographic Station Data	375, 000
Geology	18, 000
Biology	8, 000
Surface Currents	2, 500, 000

Based on Council evaluation, steps will be taken in FY 1969 to strengthen NODC and thus more evenly match its capabilities with requirements for prompt and more complete data services. In addition to continuing accession and service operations, NODC plans to:

—acquire and put in operation a modern computer facility;

—add new areas such as ocean engineering, subsurface current observations, ice measurements, bottom photographs, and data acquired from spacecraft;

—review major current research and survey efforts from the viewpoint of useful supporting services;

—reduce the backlog of high-quality, unprocessed data;

—increase advisory services;

—improve coordination with other centers.

The Navy's Fleet Numerical Weather Facility at Monterey, California, is the hub of the Naval Environmental Data Network and the center for an environmental computer program. For rapid data exchange, a data link is being established between NODC and Monterey.

National Weather Records Center

The National Weather Records Center, located at Asheville, North Carolina, is operated by the Environmental Data Service of the Environmental Science Services Administration. The Center is the major library for marine meteorological data, including sea surface temperature and ocean wave data, forwarded from 2,500 merchant ships and a much smaller number of fixed stations, such as ocean station vessels and lightships. This provides a broad base of marine climatological punched cards for exchange with members of the World Meteorological Organization. In addition, the Center summarizes marine meteorological data on a reimbursable basis for use in Marine Climate Atlases prepared by the Navy, in *Coast Pilot* publications issued by the Coast and Geodetic Survey, and in *Sailing Directions* issued by the Naval Oceanographic Office. A communications system for data exchange is planned to link the National Weather Records Center with the National Oceanographic Data Center.

New programs will be initiated at the Center in FY 1969 to convert marine meteorological data to an internationally approved format preparatory to developing an international Marine Atlas for the World Meteorological Organization and to perform an analytical study of sea surface temperature data.

Great Lakes Data Center

The Great Lakes Data Center, operating under the Corps of Engineers in Detroit, Michigan, was established in 1963 to provide services to the Great Lakes Study Group—those agencies in Canada and the United States engaged in basic and applied research and engineering investigations related to the development and utilization of Great Lakes water resources. The Center is a branch of the United States Lake Survey, which has been involved in data collection on the Great Lakes since 1841.

Serious environmental problems affect the Great Lakes and adjacent land areas. Recognizing the need to utilize most efficiently the environmental data that have been obtained from the area, responsible agencies have developed a program directed toward processing, storage, retrieval, and dissemination of:

—hydraulic and hydrologic data (water level);
—oceanographic data (physical, chemical and biological);
—hydrometeorological data (precipitation);
—hydrographic data (depth).

Data provided by the Great Lakes Center assist in regulating the levels and overflow of Lakes Superior and Ontario and the flow over Niagara Falls, in accordance with United States-Canadian agreements; and determining the division of water for hydroelectric power between the United States and Canada. Such data are also used extensively for research studies on fisheries, pollution, shore processes, currents, and ice formation, and movement.

Smithsonian Oceanographic Sorting Center

The Smithsonian Oceanographic Sorting Center (SOSC) was established in 1963 to process biological and geological specimens for scientists throughout the world. The Center receives samples of marine algae, plankton, invertebrates, and vertebrates from oceanographic expeditions and biological field stations, sorts the samples into taxonomic groups, and forwards them to more than 250 systematic specialists—about 200 in the United States and the remainder in twenty-six foreign countries. Also, SOSC temporarily stores sea floor rock and sediment samples, makes preliminary analyses, and arranges for their assignment to competent investigators for study. Major sources of biological and geological collections received by the SOSC have been the International Indian Ocean Expedition, United States Antarctic research program, International Cooperative Investigation of the Tropical Atlantic, and Guinean Trawling Survey. Fifty-one sources have supplied 35,000 samples, including 6,000,000 specimens, for identification and study; 8,000 have been sorted.

The SOSC lacks resources to handle the incoming flow of materials, as evidenced by the fact that only one in four samples received has been processed and forwarded for scientific study. It is planned to identify priorities more clearly to determine what changes are necessary to achieve greater effectiveness in the Center's operation.

Data Management Study

The Marine Sciences Council initiated last year a comprehensive data management study jointly funded by participating agencies.

The study is proceeding in two phases to identify and evaluate the requirements for information and data management to support all aspects of na-

tional marine resource and engineering development activities, as projected for the next ten years. The first phase was designed to:

—review and analyze the findings of related studies of data management, such as the feasibility study on a national buoy system;

—assess customer requirements for marine data;

—survey the relevant literature on storage, retrieval, and reduction of marine data;

—collate the plans of selected agencies for the development of improved oceanographic data handling capabilities;

—develop a detailed plan for the second phase.

An interagency advisory group and a panel of consultants—representing Government and industry—were established to evaluate both Federal and non-Federal requirements and to monitor the study.

The first phase determining the specific scope and structure of the study is now complete. Interviews by the contractor study team were held with representatives of 28 Federal agencies and departments and with representatives of the scientific, educational, and industrial community throughout the country.

The nature of future data requirements to be considered in developing recommendations for a national marine data program were found to be:

—broader geographical coverage;

—increased synoptic data collection;

—greater use of instruments which record several parameters concurrently;

—increased integration of marine and meteorological data collection and analysis;

—stronger emphasis on multi-agency and multi-national cooperative survey programs;

—greater use of expendable instruments to facilitate shipboard measurements;

—increased volumes and diversity of data collected;

—greater need for standards and quality control to facilitate multi-organizational collection and exchange of data;

—steps to handle perishable data resulting from an increase in synoptic data use; and

—recognized need for space-time correlation, not only for marine data but combinations of marine and meteorological data.

The study will proceed in 1968 into its second phase, to identify and forecast data requirements; to delineate a national data program, with a transition plan to attain coordination of existing marine data and information service functions; and to determine cost estimates for the principal components and competitive alternatives. The study will include recommendations on data management improvement for the Federal agencies and

related data centers, including priorities. An inventory of marine information services will be developed to:

—define existing data sources (prime producers and data centers);
—describe their holdings, services, data availability, and cost;
—describe the procedures for obtaining data and other services from these sources.

Preparing for the Future

The complex problems associated with the flow of marine sciences data from acquisition to end-product are being approached by planning for data handling over the next ten years. If not resolved, problems of poor service, slow response time, and higher costs than necessary will intensify in the future. The data study to be completed early in 1969 will indicate how data functions and activities might logically evolve on a national scale to achieve progress in providing the kinds and quality of services needed by all sectors of the marine science affairs community.

"Basic research is the cornerstone on which the successful use of the sea must rest."
—JOHN F. KENNEDY

Chapter X

SCIENTIFIC RESEARCH

REALIZATION of the potential benefits of the sea discussed throughout the report depends on a strong core of scientific research. Yesterday's studies to increase understanding of the ocean have made possible explicit achievements today. In recent years we have seen dramatic examples of the direct payoff of research reflected in such endeavors as our naval capabilities, weather prediction services, and off-shore oil production. While all of the benefits in the 1970's and 1980's which will result from current research programs are not predictable, the demands on the marine environment are certain to grow. We have learned from experience in many other fields that we will be able to respond to those demands only if a vigorous base of science is maintained.

That the successful attainment of marine science goals depends on classical scientific and engineering fields is portrayed in Table X.1. Also shown are examples of gaps in present knowledge. The Table subdivides each purpose into smaller tasks for accomplishment and shows that many areas of marine sciences have application to more than one purpose. Physical oceanography, for example, has relevance to all the purposes. While the Table is not inintended to be comprehensive, it provides a broad framework for relating research programs to explicit needs; it may thus serve as a qualitative guide to research content discussed in other chapters. The Table does not, of course, reflect the institutional vehicles essential for the successful transfer of scientific discoveries to practical needs. But the contributions of science derived mainly from university research are important equally to Government and to industry.

Table X.1—Marine Science and Technology for Attaining National Goals

National Goals	Scientific/Engineering Fields	Research Needs
ENHANCE TRANSPORTATION AND COMMERCE		
Sea State-Weather Forecasts	Physical Oceanography-Meteorology	
	1. Circulation Systems-Global & Smaller scales	Synoptic year-round measurements; Polar ocean work
	2. Energy momentum, matter transfer	Instruments & controlled area studies
	a. Air/sea coupling, effects	Better and more sensors and measurements
	3. Origin, life, fate of icefields	Spacecraft observations
Navigation Improvements	Navigation Methodology	Need for position determination (relative to sea floor)
	1. Electromagnetic	
	a. satellites	More satellites, inexpensive receivers
	b. magnetic fields	More quantitative details
	c. laser	
	d. long wave radio	
	2. Acoustic	Longer range transmission-reception
	3. Gravitational	More quantitative details
Vehicle Improvements	Naval Architecture	Larger pay loads; faster trips; all weather travel; longer duration
	1. Submarines	
	2. Hydrofoils	
	3. Conventional hulls	
	Power-Propulsion Plants	Faster, more economical operations
Harbor & Approaches Improvements	Port Facilities	Handle larger ships and cargoes, faster
	Channels & Anchorages	Facilities for larger ships; offshore servicing
	a. Physical oceanography of shoaling	Better instruments; mechanics of sediment motion

Shore & Harbor Stabilization	Physical Oceanography—Coastal	
	1. Circulation Systems	Longer lived, greater range of tracers
	Geological Oceanography	
	1. Dynamics of sediment transport	Instruments to measure sediment motion
	2. Sedimentation processes	*In-situ* observations & measurements
	3. Coastal geology-structure stability	*In-situ* tests for shear strength of soils
	4. Morphology-Bathymetry	Maps of greater detail
	Coastal Engineering	
	1. Protective structures-stabilization	Instruments for better knowledge of forces
	2. Effects of structures, dredging & shore modification on circulation & resources	Scaling law-correlations; field instrumentation; long-term regional planning
	3. Restoration from storm or accident damage	Areal maps of volumes of material involved; better clean-up methods for spills
Flood and Storm Warning	Physical Oceanography	
	1. Air/sea coupling, effects	Instruments & controlled area studies
	a. storm surge, tides	Model tests; field implementation
	2. Wave generation, propagation	More data to test hypotheses
	a. tsunamis	Field tests-implementation
	3. Normal, abnormal circulation systems	Longer term trends-variances
	Coastal Engineering	
	1. Surge effects in harbors	Knowledge of flows, volumes & forces involved
	2. Earthquake protection	Define offshore faults; install seismometers
PROTECTION OF HEALTH		
Identification of Pollutants	Public Health Engineering	
	1. Physical, chemical, biochemical characterization of contaminants and behavior	Comprehensive identity of pollutants—sources, locations and amounts

Table X.1—Marine Science and Technology for Attaining National Goals—Continued

National Goals	Scientific/Engineering Fields	Research Needs
Distribution of Pollutants	Physical Oceanography	
	1. Circulation systems—estuaries and oceans	Better tracers—annual, secular variations
	2. Advection-mixing, shallow & deep	Instruments, techniques, measurements
	Chemical Oceanography	
	1. Sources, distribution of natural elements	More (planned) measurements
	2. Reactions, cycles and rates of	Develop analytical techniques
	Biological Oceanography	
	1. Factors of productivity—variations	Synoptic coverage—year around
	2. Species, number and distributions	More taxonomists—systematicists, inputs
	3. Ecology—influence of environment	Controlled area studies—quantitative samplers
Effects of Pollutants	Monitoring	
	1. Distribution of contaminants in: (a) environment (b) organisms	Apply existing technology—screen organisms as monitors
	2. Effects on ecosystems, synergistic	Initiate work on synergistic effects
	3. Standards of pollution	Develop for different ecosystems
	4. Enforcement	Develop for different situations
Biomedical Applications	Pharmacology, Toxicology	
	1. Isolation and biochemical identification	Increased screening of marine specimens
	2. Characterization of physiological action	Improved bioassay and chemical assay methods and application of pharmacological techniques

UTILIZATION OF NON-LIVING RESOURCES		
Locate, Identify, Characterize, & Measure Mineral Resources	Bathymetric Charts to Locate Deposits	Position control, identification of topographic details
	Geophysical Oceanography for Anomolies	Better coverage by all geophysical techniques of same areas
	Geological Oceanography	
	1. Sediments, rock composition	More cores, drilling from subs, and on sea floor, stratigraphic & offshore logging
	2. Paleontology—geologic history	
	Physical Oceanography—relative to sea floor	Sedimentation, drift processes
	Chemical Oceanography—relative to sea floor	Better ship analytical equipment; mineralization—component, effects, additions, rates
	Biological Oceanography—relative to sea floor	
Mineral Acquisition	Mining Engineering of sea floor minerals	
	1. Platforms, mining machinery	Feasibility studies—extrapolate land techniques
	2. Material handling	Do.
	3. Extraction processes	Do.
	4. Residues, handling, disposition	Do.
Mineral Utilization	Processing, Marketing	Do.
REHABILITATION OF COMMERCIAL FISHERIES		
Locate, Identify, Characterize and Measure Fish Populations	Biological Oceanography	
	1. Factors of productivity, variation	Abundance, distribution, time studies
	2. Productivity—food webs	Food habit-energy flow studies
	3. Ecology of fishes	*In-situ* observations, natural life chemistry

Table X.1—Marine Science and Technology for Attaining National Goals—Continued

National Goals	Scientific/Engineering Fields	Research Needs
REHABILITATION OF COMMERCIAL FISHERIES—continued		
Locate, Identify, Characterize and Measure Fish Populations—Con.	Fisheries/Marine Biology	
	1. Life cycles, habits, time, space	Larval fish identification & distributions
	2. Genetics, hybridization	Controlled tests, subpopulation definitions
	3. Diseases—parasites	Fish parasistologists—laboratories
	Chemical Oceanography	
	1. Salts, nutrients, trace elements—distributions, cycles and rates	Extend range of autoanalysers and equip ships
	2. Chemical forms of elements—distribution	Explore organic compounds—complexes
	Physical Oceanography	
	1. Circulation systems, large, small scales	Secular variations; relationship to fishes
	2. Temperature-density structure	Continuous time series data of changes
Fish Harvesting	Vessel, Fleet Systems Engineering	
	1. Fish locating	Improved sonar
	2. Fish herding, capturing	*In-situ* observations (submersibles)
	3. Fish handling	Mechanization
	Aquaculture	Trials with shellfish, and finfish
Fish Processing	Food Sciences—Engineering	
	1. Fish handling, processing, packaging.	Mechanization, optimize systems
	2. Preservation, refrigeration, dehydration, irradiation	Biochemical, bacteriological studies of tissues
	3. Product development—FPC, oil, latent fishes uses	Fractionation processes for more species which are available

Marketing, Distribution, and Management	Economics 1. Measure of gains—effect on goals Management 1. Conservation of resources 2. Regulation, local, national, international	 Improve catch statistics Minimize institutional barriers
ENHANCE NATIONAL SECURITY		
Develop Under standing of Processes of the Structure, and of Physical, Chemical, Biological and Geological Properties of the Oceans, their Boundaries and their Contents that affect Naval Operations.	Physical Oceanography 1. Circulation systems—local to global 2. Structure a. stability vs. depth b. geographic distribution c. temporal variations 3. Gravity waves a. surface b. internal 4. Energy, momentum, matter transfer a. at air/sea interface b. within water c. at sea/floor interface 5. Environmental prediction 6. Optical effect in the ocean a. transmission scattering b. organism effect on light transmission Chemical Oceanography 1. Chemical processes of ocean 2. Properties, amount & distribution of elements (a) inorganic (b) organic	For Physical Oceanography: 1. Synoptic observations 2. Development of advanced instruments 3. Large geographic scale experiments For Chemical Oceanography: Development of advanced instruments

Table X.1—Marine Science and Technology for Attaining National Goals—Continued

National Goals	Scientific/Engineering Fields	Research Needs
ENHANCE NATIONAL SECURITY—con.		
Develop Understanding of Processes of the Structure, etc.—Continued	Biological Oceanography 1. Biology and control of biodeterioration a. boring and fouling organisms 2. Identification, distribution and biology of dangerous marine animals a. protection *vs.* dangerous animals 3. Acoustic effects of marine organisms 4. Identification, distribution and biology of bioluminescent organisms 5. Nutritional requirements and distributional biology of lower trophic forms Submarine Geology and Geophysics 1. Sea Floor physiography 2. Sedimentary processes a. origin and state b. structures c. physical, chemical, biological, characteristics d. earth's crust and mantle, physical properties e. gravity and magnetic fields	For Biological Oceanography: Development of advanced instruments Development of new observational techniques For Submarine Geology and Geophysics: Strengthen program in energetics. and signal processing

3. Elastic wave propagation in sediments and rock 4. Applications to engineering 5. Applications to underwater acoustics	
Underwater Acoustics 1. Propagations through oceans & surroundings a. refraction b. reflection c. scattering d. attenuation 2. Natural sounds in the ocean 3. Effects of man-made sound 4. Time-variable effects 5. Mathematical models for prediction 6. Applications to: a. Develop design options b. Naval operations c. Ocean engineering d. Instruments for other science programs	For Underwater Acoustics: Closer interaction with other oceanographic areas
Arctic Environment 1. Sea ice/icebergs a. development b. spatial distribution c. properties d. forecasting 2. Physical oceanography 3. Chemical oceanography 4. Biological oceanography 5. Submarine geology and geophysics 6. Underwater acoustics	Development of instruments, suitable platforms and observational techniques

Current Research Capabilities

Our investments over the past seven years have resulted in the accelerated development of marine scientific and technical manpower, ships, and facilities. The quality of our research fleet and shore facilities is unsurpassed. Our small but growing corps of highly trained specialists provides a strong creative base of talent (see Chapter XI).

The Federal Government has accepted responsibility to make sure that academic research has grown in proportion to needs and opportunities, public and private. Federal funding for oceanographic research is shown in Figure X.1.

In addition to the research contributions of the universities, there have been many substantial contributions from Government laboratories and from industry. There are more than 90 Federal, 40 State, 90 academic, and 25 private laboratories involved in some aspect of oceanographic research.[1] These are listed in Appendix F. However, most of the basic research is carried out at 12 of our leading institutions.[2] Research has been conducted both by multidisciplinary teams and by the oceanographer, physicist, chemist, biologist, or geologist working alone. The Federal Government has drawn on scientific results of completed research and on the scientists in planning research programs. Close communication between the Federal Government and the universities has been a particularly important factor in the success of science.

The Government's oceanographic research fleet currently includes 35 vessels with 32 additional survey vessels also collecting data related to basic research efforts. Most of these ships are well equipped with modern instrumentation, and the capabilities of some of our newer ships such as the Oceanographer and Silas Bent are unsurpassed. However, a few of these vessels were built in the 1940s and are becoming more expensive to maintain and operate and need to be replaced.

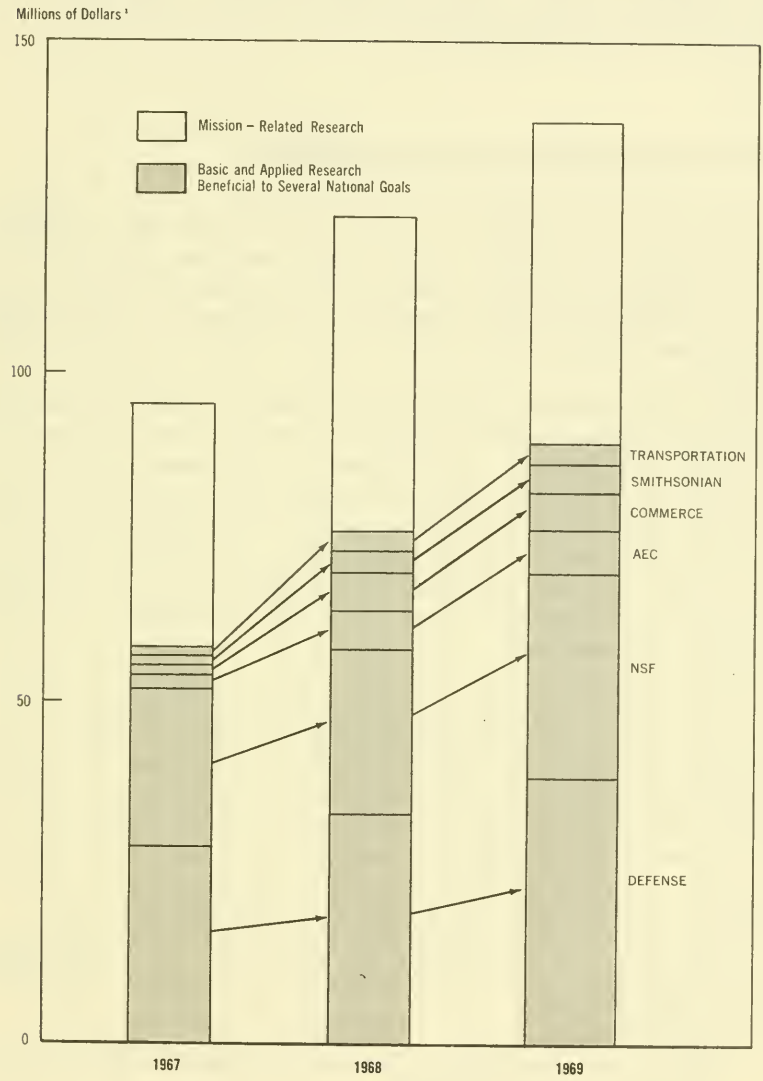
Universities operate about 40 other research ships, most of which are supported by Government funds; States and commercial organizations operate and charter others.

Recent technological advancements are rapidly providing many new tools to complement the capabilities of our research fleet. Manned deep submersibles like the Alvin, shown in Figure XII.2 in chapter XII, are justifying the vision of their early advocates and are being used increasingly as scientists fully explore their potential. U.S.-built submersibles made over 300 research dives in 1967 as compared to 140 in 1965 and 230 in 1966. Towed unmanned vehicles are making it possible to examine the deep ocean

[1] With annual budgets of more than $50,000 devoted to ocean investigations.

[2] Woods Hole Oceanographic Institution, Massachusetts Institute of Technology, and following universities: Oregon State, Washington, Texas A&M, California (LaJolla), Columbia, Rhode Island, Johns Hopkins, Hawaii, Miami (Florida), and New York.

Figure X-1— Funding for Oceanographic Research
(Showing Federal Sources of Non-Mission Related Research)



1. Excludes Coast Guard Research vessel

in new detail, and sophisticated instrument packages, capable of freefall and recovery, are collecting information long needed by the oceanographer. Buoy technology has advanced to the point where experiments requiring long time-series observations are being planned. Meteorological satellites now provide

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new insights into weather processes over the sea, and Gemini photography demonstrated the potential of space observation of ocean phenomena. Additionally, advanced laboratory models—physical and mathematical—provide important new analytical tools.

Federal Funding of Research and Facilities

Research ship operating costs are shown in Table X.2. The total Federal support of basic and applied research, including work performed in universities, industry or the Government is shown in Table X.3. Research proposed for the next fiscal year is about $14 million greater and the research ship operating costs about $3 million greater than the appropriations for FY 1968.

Many of these programs have been discussed in other Chapters, particularly those supporting specific missions. The Navy, primarily through the Office of Naval Research, supports marine science research at almost 100 universities and colleges and private laboratories and a dozen Navy laboratories. Investigations cover broad programs in ocean and sea floor dynamics; marine chemistry, geology, and biology; air-sea interactions; physics of sound in the sea; Arctic environment; radioactivity; research instrument development; human regulatory mechanisms related to diving; earth physics; corrosion; and related fields.

The Department of Defense THEMIS program to develop new academic centers of excellence includes six projects [3] in marine sciences that were initiated in 1967. The total funding of $2.92 million, which represents approximately 43% of all THEMIS funds allocated to the Navy during FY 67, provides these institutions with two full years of support which is step-funded over a three-year period. The additional FY 1968 and FY 1969 ocean science and technology expenditures under Project THEMIS are expected to amount to $4.5 million and $6.0 million, respectively, based on the same percentage allocation of total Navy THEMIS resources.

The National Science Foundation has increasingly supported marine research, facilities, and education at universities and oceanographic institutions. The NSF program:

—funds for ship construction and conversion;

—supports the construction of laboratory buildings, docking facilities, and other shore installations;

[3] State University of New York at Buffalo—*Environmental Physiology;* University of Massachusetts—*Deep Sea Submersibles;* University of Notre Dame—*Military Vehicle Technology;* Arizona State University—*Human Performance in Unusual Environments;* Oregon State University—*Use of On-line Computer for Environmental Research;* Florida State University—*Fluid Dynamics Center.*

—supports basic research grants;
—assumes responsibility for an appreciable part of the ship operating costs at educational institutions;
—provides management for the United States Antarctic Oceanographic Research program;
—funds a special program of deep ocean sediment coring in depths of water to 20,000 feet; and
—supports special studies, fellowships, and conferences.

While the size of the research programs of other agencies are not as large as the Navy and NSF programs, they too contribute both to meeting the needs of individual agencies and to a strengthened national research base. Among the many programs included in the multi-goal research category are research on air-sea interaction (ESSA), radionuclide investigations (AEC), activities related to phenomena of currents (Coast Guard), and analyses of marine biological and geological specimens (Smithsonian).

The Council's Committee on Marine Research, Education, and Facilities was established to assist the Council on questions of oceanographic research and engineering, vessels and facilities, and manpower and specialized education, including the Sea Grant Program. Advice is also obtained from the National Academies of Science and of Engineering. In addition, a September 1967 report prepared by the Council of Oceanographic Laboratory Directors [4] (COLD) for the Marine Sciences Council on the role of academic institutions in the development of marine resources and technology has provided valuable insights concerning Federal policies in support of research.

Table X.2—Research Ship Operating Costs by Agency
(In millions of dollars)

	Estimated, FY 1967	Estimated, FY 1968	President's budget, FY 1969
1. DOD:			
a) Dept. of Navy	5.4	7.2	8.3
2. Commerce:			
a) ESSA	0	0	0
3. Interior:			
a) Bureau of Commercial Fisheries	1.9	2.8	2.8
b) Geological Survey	.2	.2	.2
c) Bureau of Mines	.1	.3	.4
4. NSF	8.1	9.1	10.7
5. AEC	.3	.3	.3
7. Transportation:			
a) Coast Guard	1.2	1.2	1.2
	17.2	21.1	23.9

[4] The COLD institutions are listed in XI, Figure XI.4.

Table X.3—Research by Agency (Excluding Ship Operating Costs)

(In millions of dollars)

	Estimated, FY 1967	Estimated, FY 1968	President's budget, FY 1969
1. DOD:			
a) Dept. of Navy	20.3	21.2	23.7
THEMIS	2.9	4.5	6.0
b) Dept. of Army	3.2	3.4	3.9
c) ARPA	1.8	.7	0
2. Commerce:			
a) ESSA	2.6	3.5	4.5
b) Maritime Administration	2.4	5.6	2.9
3. Interior:			
a) Bureau of Commercial Fisheries	10.1	10.8	11.0
b) Geological Survey	2.8	3.1	3.0
c) Office of Saline Water	.6	.9	1.0
d) Bureau of Sport Fisheries and Wildlife	1.4	1.7	2.5
e) Bureau of Mines	.2	.1	.2
f) Federal Water Pollution Control Admin.	1.8	2.9	3.7
4. NSF	14.5	24.1	28.0
5. AEC	4.8	5.1	5.1
6. HEW:			
a) Public Health Service	3.6	4.0	4.2
b) Food and Drug Administration	.3	.4	.6
c) Office of Education	1.1	1.2	1.5
7. Transportation:			
a) Coast Guard	.5	.5	6.1
8. Smithsonian	1.3	1.3	1.4
9. NASA	.1	1.6	1.6
Subtotal	76.3	96.6	110.9
Research Ship Operation Costs	17.2	21.1	23.9
Total	93.5	117.7	134.8

Oceanology Highlights

In 1967, the number of oceanographic cruises of U.S. ships increased by 14 percent over 1966 and by 40 percent over 1965.[5] The following areas of investigations exemplify the breadth of research conducted during several of these cruises in 1967:

—climatic changes caused by variations in the Earth's orbital parameters;
—chemical processes involved in the formation of manganese nodules on the ocean floor;
—mechanisms of ocean layer mixing of gases;
—naturally occuring insecticides in a tropical estuary;
—a new fracture zone in the Atlantic postulated on the basis of earthquake epicenters;
—relationship of upwelling off the Indian coast to the onset of the monsoon.

The number of national and international meetings in the marine sciences increased by 68 percent in 1967 over 1965,[6] and there was also a significant increase in the number of articles related to marine sciences published in some 1700 scientific and engineering journals.[7]

One of the most exciting scientific advances in 1967 in the field of marine geology and geophysics was deduction from empirical evidence of ocean floor spreading. Basically, this concept states that rock within the earth's mantle flows very slowly over millions of years and rises under the mid-ocean ridges to continually form new oceanic crustal rock. The plastically flowing rock then spreads very slowly along the seabed away from the crest of the mid-ocean ridges in both directions dragging the newly formed crust of rock along. Finally, the rock circulates downward at continental margins.

Recently, new data have been brought to bear on the validity of the concept. Evidence has come from measurements of the earth's magnetic field of the mid-ocean ridges and from first motion studies of earthquakes associated with the fracture zone that offset the ridge axes. Results have shown that the relative motion across the fracture zone is just that expected from the ocean floor spreading hypothesis. Ocean scientists are providing evidence that the solid earth is unstable and in a sense flows; marine geology and geophysics likely will tell us the rate of motion.

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[5] ICO publications 16, 22, and 27; Oceanographic Ship Operating Schedules FY 1965, 1966, and 1967.

[6] *International Marine Sciences,* UNESCO and FAO, published in 1965, 1966, 1967.

[7] Based on a review of listings in *Oceanic Index,* Mission Bay Research Institute, LaJolla, California.

New Research Programs

1. A New Emphasis on Arctic Research.

The scientific and strategic importance of the Arctic region has long been recognized. Now as shipping and air travel increase in the polar latitudes, and the Arctic becomes a more attractive potential source of oil, minerals, and seafood, Arctic research is taking on added significance.

In recognition of this importance, the development of capabilities to conduct oceanographic research in polar and sub-polar areas was selected by the Marine Sciences Council as an area deserving priority attention during FY 1969. Last year the Council recommended that a replacement Coast Guard ship authorized for the International Ice Patrol be especially designed and equipped so that oceanographic research in the high latitudes could be expanded. However, funds were not appropriated for the ship in FY 1968 and the Council has recommended that $14.5 million be provided in FY 1969. During the past year construction began on a new research facility for the Navy Arctic Research Laboratory at Point Barrow, Alaska. The FY 1969 budget contains $2 million to improve this facility.

In addition, the Council requested its Committee on Marine Research, Education, and Facilities to undertake a study of Federal research activities in the Arctic and future needs.

2. Marine Pharmacology.

In the last few years the sea has become the source of a number of substances used in medicine, and there has been growing attention to marine sources of pharmaceuticals. The value of biochemical studies of marine plants and animals is indicated by certain antiviral, antimicrobal, and an array of pharmacological effects found in toxins and chemicals recovered from marine sources. The future value of these sources for medicinal purposes is almost entirely unknown; research is just beginning.

During 1967 an *ad hoc* Committee on Marine Pharmacology and Toxicology was established by the Marine Sciences Council as a basis for stimulating the development of a more broadly based marine pharmacology program.

3. Air-Sea Interaction.

The Federal Council for Science and Technology has assigned the responsibility for developing a Federal Program for Air-Sea Interaction Research to the Department of Commerce. This task was accomplished in 1967 in consultation with all interested agencies. As part of the program, a Barbados Oceanographic Meteorological Experiment—BOMEX—will be conducted from May to July 1969 in the area east of Barbados with funding

and participation by seven Federal agencies.[8] A pilot investigation will be executed on and near Barbados by ESSA and Florida State University from June to August 1968.

Continuing Importance of Basic Research

The Federal Government has played a major role in the support of basic research generally and marine research specifically. It has endeavored to strengthen the research base, through intensified academic science, constructing modern ships and laboratories, and supporting education and training to insure a continuing influx of talented people into the field. The base of scientific competence must now be further developed. The smaller laboratories, as well as the larger well-established centers, must be strengthened and contributions from a wide range of individual scientists must be encouraged.

The Marine Resources and Engineering Development Act has given new focus to the benefits to be derived from application of scientific discovery that adds significance to the research itself. Continued excellence is essential to effectively use the sea. The Marine Sciences Council has accordingly selected basic research as deserving special attention, with emphasis on research conducted at academic institutions.

[8] Departments of Commerce, Defense, Interior and Transportation and the Atomic Energy Commission, National Aeronautics and Space Administration, and National Science Foundation.

"In our research-oriented, innovative society we have an unprecedented opportunity to encourage all our citizens to be creative, each in his own way. Science and technology can hasten the achievement of this goal if we deploy and use our creative talent wisely."—COMMITTEE ON UTILIZATION OF SCIENTIFIC AND ENGINEERING MANPOWER OF THE NATIONAL ACADEMY OF SCIENCES

Chapter XI

MANPOWER: EDUCATION, TRAINING, AND FACILITIES

SKILLED manpower is essential for a nation to advance in science and technology.

Availability of manpower—in terms of quality as much as quantity—becomes all the more critical in the field of marine sciences and technology because at this stage of development, it is skill-oriented rather than capital-oriented. Except in the military and petroleum areas, technological developments have not yet occurred that warrant large investments for production and operations. Compared with many other fields, there is a higher concentration of activity in research than development. New achievements are paced in large measure by individual talents.

In recent years, the Federal Government has assumed a major responsibility—as a matter of national policy—for the support of training and education through a wide range of fellowships, training grants, research and institutional programs. This Federal policy has significantly strengthened the marine sciences.

Graduate enrollments and the number of degrees granted annually in the field of oceanography have increased substantially during recent years as suggested by Table XI.1, a gratifying product of investments in oceanography that began to increase in the early 1960's. Support for education of marine science technicians and ocean engineers, however, has appeared to lag behind corresponding support for other fields. The importance of

technicians may have previously been underestimated with the consequence that the present shortage of supply may impede effective utilization of leadership-level scientists.

Table XI.1—Oceanographic Degrees Granted, 1960–1967, at C.O.L.D.* Institutions

Academic year ending	Full time graduate student enrollment	Degrees granted	
		M.S.	PhD
1960	92	9	6
1961	105	14	9
1962	126	22	12
1963	188	22	8
1964	221	41	9
1965	[1] 520	35	25
1966	[1] 800	N.A.	N.A.
1967	[1] 980	[2] 99	[2] 60

*Council of Laboratory Directors Report, September 1967. These Directors represent the following institutions: Institute of Marine Sciences, University of Miami (Florida); Department of Oceanography, Oregon State University; Department of Oceanography, University of Washington; Department of Oceanography, Texas A&M University; Scripps Institution of Oceanography, University of California (LaJolla); Lamont Geological Observatory of Columbia University; Woods Hole Oceanographic Institution; Graduate School of Oceanography, University of Rhode Island; Department of Oceanography, The Johns Hopkins University; Institute of Geophysics, University of Hawaii.

[1] Estimated.

[2] Minimum; M.S. in Oceanographic Sciences only; PhD. in Oceanography only.

Table XI.2—Employers and Professional Specialties of Oceanographic Personnel in the U.S., 1964 and 1967

Type of Employer	Oceanographer		Fisheries Scientist		Oceanographic Engineer		Ocean. Fisheries Technician		Non-Oceanographic Technician and Eng.		Marine Intern		Total	
	1964	1967	1964	1967	1964	1967	1964	1967	1964	1967	1964	1967	1964	1967
Federal	184	316	74	85	47	324	125	614	284	1,039	180	315	894	2,693
State & Local	49	35	72	104	2	4	4	82	30	20	71	37	228	282
University	320	556	17	37	37	126	34	140	201	221	128	155	737	1,235
Industry	17	60	1	3	35	168	3	32	111	209	14	88	181	560
Non-Profit	47	81	1	1	5	12	9	33	19	36	26	22	107	185
Others	14	11	6	8	1	3	1	2	12	3	4	------	38	27
Total [1]	631	1,059	171	238	127	637	176	903	657	1,528	423	617	2,185	4,982

[1] Students have been excluded. In 1964, there were 464 students who fit the criteria for inclusion; in 1967, 783 students qualified as oceanographic personnel.

Note: In 1964, there were 3693 questionnaires returned of which 2649 qualified for the categories. The 1967 survey produced 7500 total responses with 5765 meeting the criteria for inclusion.

Source: A Study as to the Numbers and Characteristics of Oceanographic Personnel in the United States, 1964, NSF Contract—C331. A Study as to the Numbers and Characteristics of Oceanographic Personnel in the United States, 1967, NSF Contract—C469, both by the International Oceanographic Foundation.

Table XI.3—Ocean Science Curricula, 1962–1968

Category of Curriculum and Degrees Offered	Numbers of Institutions where Curricula Offered	
	1962–63 [1]	1967–68 [2]
Oceanography:		
baccalaureate	1	7
masters	10	15
doctorate	10	17
Marine Sciences:		
baccalaureate	0	1
masters	7	9
doctorate	6	9
Biological Sciences (with marine option):		
baccalaureate	5	12
masters	15	22
doctorate	13	16
Earth/Physical Sciences (with marine option):		
baccalaureate	4	9
masters	11	19
doctorate	10	18
Ocean Engineering:		
baccalaureate	0	2
masters	0	7
doctorate	0	3
Applied Fisheries:		
baccalaureate	2	2
masters	3	3
doctorate	2	2
Taxonomy-Systematics:		
diploma	1	1
Technical School:		
Certificate or Diploma		3

[1] Data from ICO Pamphlet No. 6, June 1962, "University Curricula in Oceanography."
[2] Data from ICO Pamphlet No. 30, Aug. 1967, "University Curricula in the Marine Sciences."

Table XI.4—Institutions Offering Marine Sciences-Engineering-Technician Training, 1962–1967*

(Degrees held by teaching staffs in parentheses)

Degrees offered	Number of schools having Marine Curricula	
	School Year 1962–63	School Year 1967–68
Oceanography	10 (132 PhD) (14 MS) (6 BS)	21 (270 PhD) (20 MS) (5 BS)
Marine Sciences	7 (36 PhD) (5 MS)	11 (95 PhD) (21 MS) (2 BS)
Ocean Engineering	0 ----------	9 (58 PhD) (24 MS) (8 BS)
(Applied) Fisheries	3 (est 25 PhD)	3 (31 PhD)
Life/Earth Sciences	20 (86 PhD)	32 (217 PhD)
(with marine orientation)	------(8 MS)	(8 MS)
Taxonomy Systematics	----------	1 ---------
Technology	----------	3 (1 PhD) (6 MS) (6 BS)
Total number of schools reporting	35	63

*Based on data provided to ICO and reported in ICO Pamphlet No. 6, June 1962 and Pamphlet No. 30 Aug. 1967.

Manpower Currently Available

In 1963 and in 1967 the National Science Foundation supported surveys of personnel engaged in oceanographic activities. The results, reported by work specialty and by employer, are presented in Table XI.2. The data indicate a doubling of the total number of specialists in the field during the four years although this difference is probably due to broader coverage of engineers in the second survey. The survey also indicates that only about 60 percent of the specialists in the field in 1963 remained in the field, which further emphasizes the large recent influx of new participants.

Educational Opportunities

A survey of marine science curricula was completed during 1967 by the Council's Committee on Marine Research, Education, and Facilities. Some of the findings presented in Tables XI.3 and XI.4 indicate that the demand for ocean scientists and engineers has resulted in the establishment of new curricula and new departments at colleges and universities interested in the field for some years as well as entry of new schools. More schools are offering baccalaureate degrees in marine specialties, and some schools now offer ocean technician training. The fastest growth has been in ocean engineering. None of the institutions surveyed five years ago offered courses in ocean engineering while today two offer a bachelor's degree, seven a master's degree, and three a doctorate.

Few students can independently afford the training necessary to attain a high level of competence in marine science. The following Governmental programs of student assistance find application in the marine sciences:

—National Defense Graduate Fellowship Program, National Defense Student Loan Program, the Guaranteed Loan Program (graduate and undergraduate), and the Educational Opportunity Grants Program (undergraduate) administered by the Office of Education of the Department of Health, Education, and Welfare;

—grants to elementary and secondary school systems for developing innovative programs under the Elementary and Secondary Education Act of 1965 administered by the Office of Education of the Department of Health, Education, and Welfare;

—graduate fellowships by the Department of the Interior's Bureau of Commercial Fisheries (about 20 per year);

—stipends from the Smithsonian Institution for post-doctoral studies and summer research training;

—fellowships, traineeships, faculty research training, and support of course and curriculum improvement by the National Science Foundation.

Support for marine sciences under these programs has been estimated as follows:

(In millions of dollars)

	FY 1967	FY 1968	FY 1969
Department of Health, Education and Welfare	1.1	1.2	1.5
Department of the Interior	.2	.2	.2
Smithsonian Institution	(*)	(*)	(*)
National Science Foundation	1.6	1.7	1.9

*Less than $50,000.

The Department of Commerce, Defense, and Transportation support graduate training and education for their employees to aid in career development. For example, the Navy operates its own post-graduate school at Monterey, California, and the Coast Guard operates an eight-week oceanographic technician school. The programs cost:

(In millions of dollars)

	FY 1967	FY 1968	FY 1969
Department of Commerce	.1	.1	.1
Department of Defense	.9	1.2	1.3
Department of Transportation	.1	.1	.1

Additionally, the National Science Foundation supports about 300 post-graduate marine science students as research assistants on grants, the Office of Naval Research about 200, and the Atomic Energy Commission approximately 50. One benefit of this education-research arrangement is that the student, by participating directly in the research, is afforded an opportunity to obtain first-hand sea-going experience, although this arrangement may prolong the time to obtain a degree. It is estimated that about one-half of the graduate students in marine science obtain some assistance through these programs, and most graduate students engage in part-time teaching or work as research assistants.

In addition to Federal sources of support, there are a number of assistance programs sponsored by the States and by industry, but these are small by comparison.

Initiation of the Sea Grant Program

Recognizing the importance of manpower, engineering research, and institutional development to future growth in marine sciences, the Congress in 1966 passed the National Sea Grant College and Program Act (Public Law 89–688). The Act, signed into law on October 15, 1966, charges the National Science Foundation with initiating, developing, and supporting the programs authorized by the Sea Grant Act. It requires the Marine Sciences Council to advise the Foundation with respect to the policies, procedures, and operations of the Foundation in carrying out its functions.

The Sea Grant Program has three explicit objectives:

—to accelerate training and education of specialized manpower, especially ocean engineers and technicians, required by industry

and government which are not being developed through programs;
—to initiate and support applied research, in predevelopment stages, particularly related to recovery and utilization of marine resources;
—to disseminate knowledge and information about marine resource development to all interested and concerned sectors of the nation.

The Sea Grant Program includes two categories of support—Institutional and Project.

Institutional-type Sea Grant Programs are intended to strengthen marine science programs of colleges and universities engaging in multi-faceted activities that embrace education, research, and advisory services. Institutions are selected on such factors as ability to perform special studies of differing marine ecologies or resource problems, or for specialized experience in other fields. Institutions thus have an opportunity to concentrate research on problem areas of greatest regional interest and concern. Following a trial period, an institution may be designated a Sea Grant College.

The Sea Grant College provision is intended in the first instance to enlarge the base of funding but it should be especially valuable in providing longer term, broader based support to academic institutions than is generally possible through the project grant system. It should also encourage inter-disciplinary approaches to broad problems and enhance communication between classical disciplines so often isolated within a university.

Under the second type of support, Sea Grant Projects are intended to advance scientific, engineering, and technological know-how, especially at the stage where scientific discovery first blends into a possible social application, but also where practical economic benefits are still uncertain. This mechanism also provides a means for responding to varied and changing research needs of the Federal Government and is of particular importance in complementing programs of agencies not having broad extramural programs, or supporting research on topics that cross missions of various agencies and fail to gain the interest of any one. In the future, the Government may express such interest through announcements by the National Science Foundation, to invite attention and participation of the non-Federal research, study and industrial community to meet these needs.

Support in this category will encompass more than research projects. The legislation intended support for symposia and conferences, for the development of innovative educational curricula and for new programs needed for training of critical or specialized technological skills.

Thus, the Sea Grant legislation provides for grants and contracts to public or private institutions of higher education, institutes, or laboratories—for education, applied research and information transfer aimed at marine resource development. Matching funds equal to one half the Federal grant

or contract, i.e., one-third of the total, must be obtained from sources other than the Federal Government. Federal funds may not be used for construction or rental of facilities. Participants in any one State may not receive more than 15 percent of the total appropriation to the Foundation for the Sea Grant program in any fiscal year.

The Sea Grant program is being carried out at universities, but with the expectation that the Federal and State Governments, the academic institutions, and industry will examine common problems and pool diversified resources, facilities, and specialized talents for their solution. The program augments rather than replaces existing programs of support and should provide a cohesiveness among these on-going efforts.

To implement the legislation, the National Science Foundation established a new Office of Sea Grant Programs. The Foundation has also established an advisory body for each of the two types of awards to review proposals and make recommendations.

The following Sea Grant Project awards have been made:

American Association of Junior Colleges: "Planning for American Junior College Involvement in the Training of Marine Technicians."

California Institute of Technology: "Restoration, Propagation, and Management of Marine Algae."

Francis T. Nicholls State College, Thibadoux, Louisiana: "Shrimp Production in Louisiana Salt-Marsh Impoundments under Existing and Managed Conditions."

Massachusetts Institute of Technology: "Development of New Subjects for an Ocean Engineering Graduate Program at MIT."

University of Miami (Florida): "Development of Techniques for the Mass Culture of Economically Important Pink Shrimp and Pompano."

Florida Atlantic University, Boca Raton: "Establishment of a Cooperative Ocean Engineering Education Program."

On February 21, 1968, the National Science Foundation announced institutional awards to the following institutions:

University of Rhode Island, Kingston
Oregon State University, Corvallis
University of Washington, Seattle

The response to this new program—from State governments, academic institutions, business, and industry—has been enthusiastic, and the Sea Grant program has been selected by the Marine Sciences Council as a program deserving continued priority emphasis during FY 1969.

In FY 1968, $4 million is designated to carry out provisions of the Act. The budget requested for FY 1969 is $6 million.

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Investing in Manpower

Only now are we receiving the dividends of the accelerated educational and training programs of the early 1960's. Today's program must respond to the challenge of the 1970's.

The entire marine science program is dependent on an expanding base of highly skilled and innovative specialists. Ocean scientists and engineers comprise this core, but there is a growing need for specialists in many other disciplines to turn their energies and intellect to the sea—from economics, law, business, public administration, and foreign affairs.

The supply of teachers holding doctorates or masters degrees, and interested in teaching in the marine field, is not keeping pace with the demand. In fact, perhaps half of the new doctorates may be needed in educational institutions to keep pace with enrollments. At the same time, qualified students are applying faster than they can be accommodated.

While the burden of specialized marine science education has rested primarily with a very small number of educational and research institutions, as the field grows it will increasingly depend upon a broader base of universities and colleges for its scientists, engineers, and technicians.

The Sea Grant program offers a new approach to meeting national needs for technical manpower. It should benefit the Nation as a whole, and it will be of particular benefit in responding to the needs of States and communities to use marine resources for strengthening local economies, conserving limited coastal resources, and improving the quality of the environment.

"Technological—or engineering—needs of many environmental science programs are so extensive that the line between marine science and ocean engineering must be largely abolished in practice if not in theory, if many important projects are to proceed effectively." —EFFECTIVE USE OF THE SEA; REPORT OF THE PRESIDENT'S SCIENCE ADVISORY COMMITTEE, 1966

Chapter XII
ENGINEERING IN THE OCEAN

One of the most significant aspects of marine science affairs today is the changing emphasis from what was largely scientific study of the sea to its more effective use. The agent for the critical transfer of scientific results to practical application is ocean engineering.

Ocean engineering is a key to the development of the ocean's resources, to maritime transportation, to defense, and to enhanced use of shores and harbors to meet society's expanding needs.

Ocean engineering fulfills two important functions: it provides a bridge from scientific discoveries to utilization of the oceans, and it provides new, more powerful instruments and tools to observe and measure ocean phenomena. Also, as work in the oceans becomes more complex, the engineering techniques of systems analysis will increasingly be used.

The process of converting scientific knowledge to economic and social needs is not well understood, whatever the technical field may be, and in the civil applications of marine science and engineering there is the added requirement for "consensus" among the many participants. Ocean engineering—a relative newcomer in the technical world—must meet this extra challenge if it is to mature concurrently with expanding marine requirements.

General Purpose Engineering in Fiscal Year 1969

General purpose ocean engineering is a term adopted for engineering research and development that can be applied to a variety of purposes. Applications often span the missions of two or more Government agencies.

About 5% of the Federal marine science budget, divided into major categories as follows, is proposed for these programs in FY 1969:

(In millions of dollars)

TYPE OF ACTIVITY	Estimated, FY 1967	Estimated, FY 1968	Estimated, FY 1969*
Ocean Engineering (Navy)	8.2	10.7	14.9
Ocean Buoy Development Program (Coast Guard)	.3	.1	5.3**
Nuclear Power (AEC)	6.3	7.4	6.6

*Included in the funding for other categories is approximately $5 million for instrumentation.
**This program is discussed in chapter VIII.

Ocean Engineering Programs of the Navy

The Navy ocean engineering program includes studies, hardware development, and prototype installations for military underwater tasks. The primary effort is the Deep Ocean Technology Project to develop technical options and to assist the Navy to assess more precisely the technical feasibility and requirements for future undersea warfare systems. The areas being studied in relation to their potential deep ocean use include:

—manned and unmanned submersible vehicles;
—fixed and mobile bottom structures;
—engineering properties of the sea floor;
—metals and non-metallic materials;
—submersible motors, electrical components and propulsion devices;
—equipment, instruments, and tools;
—life support systems;
—long-endurance power sources.

Two major, long-range projects were selected by the Navy as initial goals—an advanced deep ocean submersible and an experimental, one-atmosphere, bottom habitat.[1]

[1] Both projects are designed as "test beds"—not for operational use, to test a wide variety of components and equipments.

During the past year, long-standing Navy programs of material development reached fruition in four areas:

—heat-treatable steel with a yield strength of 130,000 to 140,000 p.s.i. was approved for use on Deep Submergence Rescue Vehicles and other manned submersible hulls (previously approved limit was 100,000 p.s.i.);

—laboratory tests proved that one alloy of titanium can be used in salt water without cracking due to stress corrosion (earlier there were indications that alloys of this material with a high strength to low density ratio could not be used in salt water);

—alloys of nickel and copper with considerably increased strength were developed for use in submarine piping systems;

—non-destructive test methods and criteria were developed for evaluating low-density syntactic foams which are used to supplement the buoyancy of underwater vehicles.

Additional milestones in FY 1968 include modifications of the Navy's Cable-controlled Underwater Recovery Vehicle (CURV II) for enhanced reliability to depths of 2,500 feet and starting construction of CURV III for an operating depth of 7,000 feet.

Advancements were reported in the technology for designing, constructing, and operating fixed and semi-fixed habitats in which men can live and work deep in the ocean at atmospheric pressure. Such structures, which may be either on or in the sea bottom, have potential application for military missions and also for civilian tasks of permanent or semi-permanent nature such as mining. In FY 1969, this program will emphasize investigation of:

—hollow concrete cylinders for pressure-resisting structures at great depths;

—behavior and nature of sea floor sediments;

—corrosion and biological fouling;

—surveying techniques for precise determination of relative location of bottom and surface points.

Power for Underwater Tasks

Perhaps the most critical, unmet need of underwater technology is for inexpensive power sources with longer endurance. Today nearly all underwater missions, except for military nuclear submarines, are limited by the low capacities of available batteries. Advances are thus being sought to increase the energy available per pound, per cubic foot, and per dollar of

invested cost by several hundred percent. Figure XII.1 shows the competitive merits of different kinds of chemical and nuclear power sources. The merits of fuel cells is thus suggested as deserving greater emphasis, and the Navy plans such developments.

The Atomic Energy Commission program is directed toward the development of nuclear power sources from 0.1 watt to 100 kilowatts for buoys,

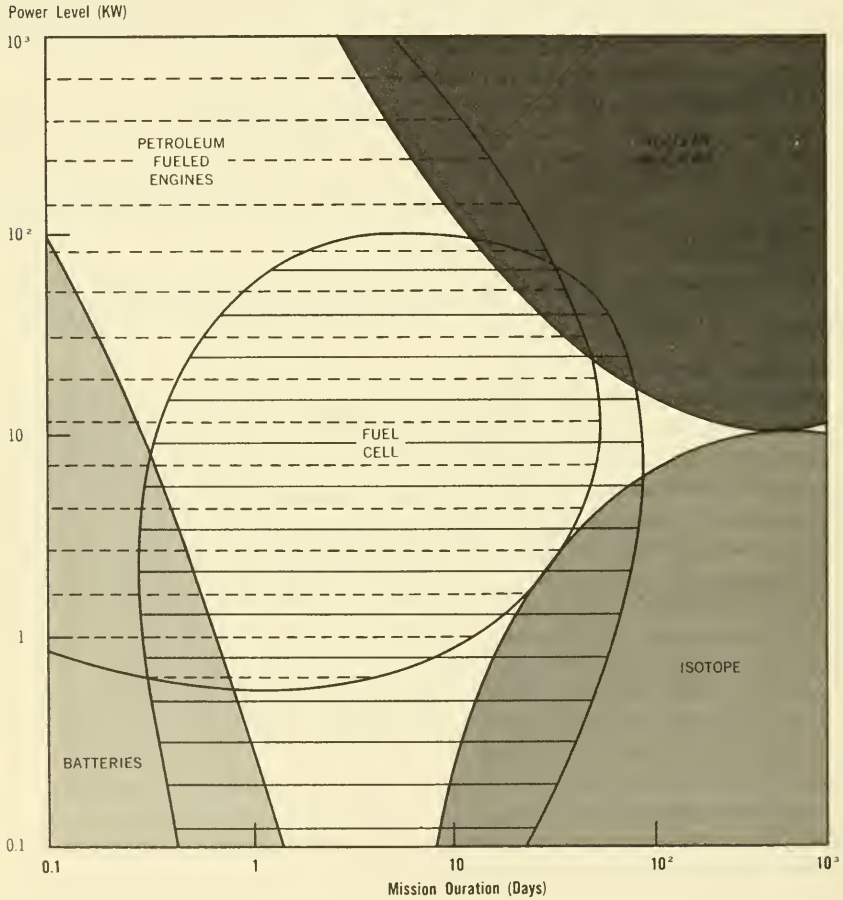

Figure XII.1. *Ranges of applicability of underwater power sources are shown here. For short-duration missions (less than 30 days) non-nuclear power sources, such as batteries, fuel cells, and diesel engines, provide the best combinations of weight, volume, power, and energy capacity, in the ranges shown by the numbers. As the planned mission duration increases beyond 30 days, nuclear power becomes more suitable, with reactors providing better overall characteristics above 10 KW, and radioisotope-powered sources below 10 KW.*

deep ocean instrumentation, vehicles, habitats, and underwater machinery. The initial emphasis and funding have been focused on design and development of first-generation isotope power devices in the power range from 5–60 watts. The objective of this initial effort has been to demonstrate the feasibility of developing isotope power sources capable of long-term, unattended operation in the marine environment without compromise of health or safety requirements. This effort, successfully completed in 1966, has established a reservoir of technology from which successive generations of power systems are being developed. New demands for higher power, from 20 kilowatts up to several hundred kilowatts, are creating an incentive for the development of reactor systems at these power levels. However, due to the long lead time required for the development and qualification of nuclear power systems (isotope and reactor), it is likely that improved batteries, fuel cells, and possibly chemically dynamic engines will fill the short-term ocean engineering applications.

New Initiatives

The programs described thus far consist chiefly of general purpose engineering which will provide a base for the technological utilization of the ocean and its resources. Repeating the emphasis of last year on Deep Ocean Technology, the Council has recommended an increase for the Navy (from $3.5 million in FY 1968 to $7.4 million in FY 1969) for long-range studies and prototype development of key ocean engineering components.

In addition, four areas involving advancing technological capabilities have also been selected by the Marine Sciences Council for special emphasis during FY 1969. The funding levels for their engineering components are summarized in the table below. While the FY 69 expenditures for these programs are small, these initial planning steps are essential beginnings for programs of national importance.

New Areas Selected by Marine Sciences Council for Priority Attention

[millions of dollars]

	FY 1969
Safety within the Sea—Department of Transportation	.3
Study of an Instrumentation Facility—Marine Sciences Council	[a]
Continental Shelf Safety—Department of Transportation	.2
Study of Frequency Allocation—Department of Transportation	.03

[a] Funds are included as part of other programs and are not reported here because the amounts for marine science cannot be accurately predicted at this time.

Safety of Manned Civilian Submersibles

Man can go deeper into the ocean, for longer periods, and do more strenuous work at almost all depths with the protection and powered assistance of a small submersible. The United States leads the world in building and using these new tools of research and industry. More than 1,000 dives have been made for research and exploration since 1964. During the past 18 months, Navy laboratories chartered several "vehicle years" of deep submersible service from private industry, while the Navy-owned ALVIN was operated full-time by the Woods Hole Oceanographic Institution (See Figure XII.2).

To insure that the growing activities of civilian submersibles are conducted safely, an integrated system of regulation is now considered necessary, including inspection of undersea vessels and structures, licensing of operators and development of a capability to rescue personnel and submersibles in distress. A new Council initiative "Safety within the Sea" calls for an extension of

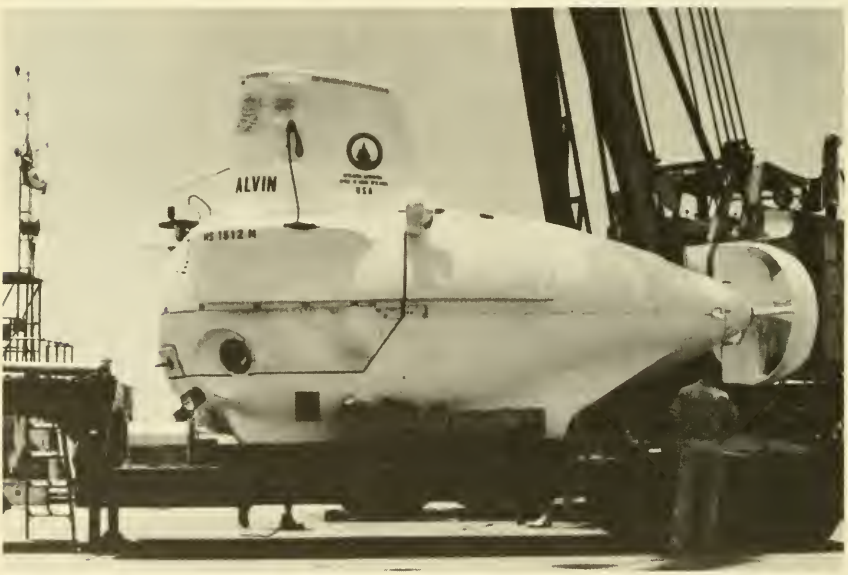

Figure XII.2. *The United States leads the world in building and using small submersibles for research and other missions under the sea. Over 1,000 dives have been performed for research and exploration since 1964. The U.S. Navy's* ALVIN *is operated by the Woods Hole Oceanographic Institution for research and recovery. Two new* ALVINS *are being built to operate at depths of 6,500 feet. (U.S. Navy photograph.)*

existing maritime safety programs to nonmilitary submersibles and includes:

- Technical aspects
  - Technical review and approved of designs and submersibles
  - Inspection during construction of equipment
  - Qualification standards and operator licensing
  - Casualty investigation
  - Operating limitations
- Search and rescue capability
- Operational control regulations
- International coordination.

This initiative will not only increase safety but should help to lower construction and insurance costs. Consideration is being given to legislation to authorize the Coast Guard to carry out these duties.

Instrumentation and Communication

Modern science and engineering depend critically on a wide variety of sophisticated instrumentation. Measurements in the ocean are more difficult than on land due to the adverse effects of the environment on reliability of instruments. Thus, one of the goals of ocean engineering is to develop better instruments, tools, and communication and navigation equipment. Important advances by the Department of Defense during the past year illustrate a variety of accomplishments:

—a wide angle (115°) lens for photographic search of large bottom areas,

—a multi-sensor "Fully Instrumented Submersible Housing" (FISH) for accurate mapping of bottom micro-structure,

—techniques and instrumentation for detecting sand transport by means of isotope tracers,

—miniaturized acoustic and inertial navigation systems for small submersibles.

To avoid the problem of wave-induced motion inherent in surface buoys, the COSMOS Underwater Stable Platform was developed by the Coast and Geodetic Survey (ESSA) to measure tides, currents and variations in magnetic field intensity. The principle of the COSMOS Platform has potential for a variety of applications that require minimum-excursion moorings for ships or large buoys. In 1966 an experimental platform was deployed off California, 110 feet below the surface in 4,500 feet of water. It was tied to the bottom by three mooring cables, arranged to be neutrally buoyant and

straight by attaching floats along the cable length. The equipment has performed well and evaluation is continuing, along with developments to achieve meteorological measurements and to permit telemetry of data.

In FY 1969, Navy, Corps of Engineers, ESSA, Bureau of Commercial Fisheries, the Coast Guard, and other agencies propose to continue their instrumentation development programs at a level of about $5 million.

Two areas were selected by the Marine Sciences Council for emphasis in FY 1969: a "Study of Frequency Allocation" and a "Study of National Instrumentation Facility." The first study, to be carried out by the Coast Guard in cooperation with other interested agencies, will consider the need for standardized underwater acoustic frequencies for non-military use to increase safety, convenience, and compatibility of new equipment. This will include distress signals and general underwater communication. The second study, to be undertaken by the Council's Committee on Marine Research, Education and Facilities, in conjunction with the National Academy of Engineering, will compile and analyze the functions, scope of activity, and organizational guidelines for a national oceanographic instrumentation center, considering possible utilization of the existing Navy Oceanographic Instrumentation Center.

Safety on the Continental Shelf

Technological advances of the past few decades and foreseeable advances indicate that extensive and varied activities will be conducted on the Continental Shelf. These include extraction of oil and gas, mineral mining, fishing, transportation, pollution control, recreation, scientific and industrial exploration. There may eventually be a need to develop mooring systems for large floating airports, floating harbors or mobile breakwaters. There may be new types of fixed underwater structures and installations, observatories and laboratories, drilling and mining complexes, storage for liquid or bulk materials, pumping and compressor stations, and processing and power generating plants. For these and similar purposes, we need improved yet economical materials; increased knowledge of the properties and mechanical behavior of sea floor sediments, wind and waves; and proven techniques for such tasks as drilling, coring, pile driving, tunneling, pipe laying, dredging, island building and waste disposal.

Conflicts between the various coastal pursuits will increase along with the amount of activity, with resultant hazard to life and property. Many of these pursuits are beyond the purview of or are only vaguely covered by existing safety legislation. A FY 1969 initiative, "Continental Shelf Safety,"

was adopted by the Council to consider problems of off-shore safety and their amelioration. The Coast Guard was recommended as the lead agency for:

—establishment of design standards and certification procedures for Continental Shelf structures and devices to reduce the likelihood of collapsing structures, bursting oil containers, or other structural accidents;

—elimination of wrecks, debris, pollutants, and litter on the Continental Shelf which may be a hazard to life or property or an interference to useful activity;

—a study of means to minimize conflicts among the various activities including: shipping, transfer of liquid or gases in pipelines, fishing, recreation, drilling, pumping, and storing materials underwater or at the surface.

Engineering for Non-Military Objectives

Private industry can and will undertake marine technology development on its own initiative where the ratio of returns to investment compares favorably in amount and timeliness to alternative ventures on land. Between these private efforts and Government military programs are areas in which the Federal Government may have to sponsor additional research and development in order to meet some of the objectives of the Marine Sciences Act. Exploration of the ocean, prediction and control of environmental conditions, major modifications of coasts and harbors, and fuller exploration of both food and minerals from the sea are cases where Federal investments in technology may be warranted.

A contract study for the Council was conducted to identify technological needs not being met by either Government or industry. These were found to be power sources and transmission, cable systems, fishing boats and equipment, submerged navigation and communication, near bottom instrumentation and open ocean handling and transfer systems.

Additional scientific information seems especially needed in:

—coastal and oceanic hydrodynamics;

—underwater soil mechanics;

—marine biology research for fisheries technology;

—exploration for mining the ocean bottoms.

Two unresolved policy issues have also been identified for study:

How can the Government support multi-purpose marine technology, serving several public interests, yet below a threshold of budget justification for any single agency?

How should marine technology required for industrial development be supported when advances of the activity are in the public interest but the returns on investment are too long deferred or are otherwise less attractive than alternate ventures available to private capital?

These two questions illustrate the institutional considerations for ocean engineering to help satisfy the requirements for future maritime endeavors.

"Tangible objects and ideas circulate throughout the Union freely. Nothing checks the spirit of enterprise. The Government invites the aid of all who have talents or knowledge to serve it." —ALEXIS DE TOCQUEVILLE

Chapter XIII

PARTNERSHIP WITH NON-FEDERAL INSTITUTIONS

While this report has dealt primarily with Federal policies and programs to study and use the seas, coastal zones, and Great Lakes, many non-Federal institutions play a distinct and important role in marine science affairs. The Federal role itself is shared with other bodies, and Federal goals cannot be achieved without cooperation. Man's use of the sea and shoreline is clearly multi-institutional as well as multi-purpose.

American private enterprise invests substantial sums in development of coastal areas, in transportation, in the exploration and extraction of off-shore oil and gas, and in fishing.

The States have rights and responsibilities as to in-shore waters and off-shore activities.

The universities and private research laboratories are key sources of basic knowledge and manpower needed by all participants.

The full development of this Nation's ocean enterprise involves cooperative activity by industry, regional authorities, State and local governments and the academic community.

Industry

Industrial investments in ocean enterprises and resources considerably exceed the approximately $500 million annually invested in the marine sciences by the Federal Government.

The value of oil and gas extracted off the United States coast now runs over a billion dollars a year, and is increasing at a rate of around 20 percent per year. Total new investment in offshore oil and gas leases has averaged over $235 million a year since 1960, and in 1967 approached $600 million on Federally administered land. Shipping, a traditional field of private enterprise, generated one and one half billion dollars in revenues, and profits totalling $150 million, for American flag shipping companies in 1966.

Also involved are other industries with substantial investments and revenues:

—high technology industries concerned with precision instruments, equipment and vehicles—primarily aerospace and electronic companies;

—industries producing economic wealth—other than shipping and fossil fuel extraction—ship and boat building, fisheries, and fish processing and marketing; magnesium and bromine extraction from sea water; and extraction of sulfur and other minerals from the seabed;

—construction and service industries such as those involved in shoreline and harbor rebuilding and dredging;

—companies that provide oceanographic services and conduct specialized oceanographic ship operations;

—coastal activities that include recreation and associated small businesses.

Industry is expected to increase its involvement substantially even as the Federal Government accelerates its own efforts. In fact, this parallel growth is one major difference between the marine sciences and outer space activities.

A substantial fraction of Federal funds for marine science and technology is spent through contracts with industry. As opportunities arise, Federal contracting for research and development helps build and maintain a base of engineering competence that can be applied broadly to future ocean developments.

We adopt as a basic premise that those activities in the past traditionally conducted in the private sector will be continued. Nevertheless, it is also recognized that, in those cases where risks are high or profits long deferred, the public interest may be served by Federal programs. At the same time, Government support of marine science and technology may have industrial

merit and applications that would render the United States competitive in the international market, or make offshore sources of resources competitive with sources on land.

The Federal Government has a variety of programs of general assistance to business which are applicable to marine industry, and some of direct assistance. Examples of Government programs to encourage development of ocean resources through industrial participation are summarized below:

A. Government Sponsorship of Research and Development:
   1. Research.
   2. Advanced engineering.
   3. Technology transfer.

B. Financial Measures:
   1. Sharing of research or capital facilities costs.
   2. Government stockpiling of strategic materials.
   3. Special encouragement programs such as Economic Development Administration projects, small business loans, land grants, foreign aid, loan guarantees, and reinsurance.
   4. Special tax provisions such as the investment credit.

C. Laws and Regulations:
   1. Laws of ownership, patents, and property rights.
   2. Leasing regulations and administration.
   3. Anti-trust laws and administration.
   4. Public utility regulations.
   5. Quasi-public-private corporations (e.g., COMSAT).
   6. Production allowables or quotas.
   7. Setting of national and international standards on equipment design, component design, etc.

D. Social Overheads and Other Social Measures:
   1. Development of human resources through education assistance programs such as Sea Grant College Program, research grants to universities, etc.
   2. Provision of forecasts, statistical and other information services.
   3. Ports, harbors, and waterway development and navigation aids.
   4. Police protection, law enforcement, and rescue services.
   5. Coastal Zone development such as recreation preserves and pollution management.
   6. Environmental prediction, oceanographic data, and mapping and navigation services.
   7. Catastrophe assistance.
   8. Public health services.
   9. War-on-Poverty, depressed area, and urban redevelopment programs, etc., in maritime regions.

E. International Measures:
   1. Projects of international cooperation in research and data gathering.
   2. Developing foreign markets for equipment manufacturers.
   3. Assistance to U.S. business firms to develop overseas ocean resources to serve foreign or U.S. markets.

During the next year, the Council and Commission will review the Nation's goals in the marine environment to consider whether special assistance is warranted and which of these various instruments may best serve the Nation's needs.

State, Local and Regional Interests

Most coastal States are already assessing problems of the Coastal Zone and many are concerned about the future economic importance of the marine environment. Marine areas of direct concern to States include:

—Continental Shelf resources within the States' jurisdiction;
—regulation of fisheries;
—control of pollution and bays and estuaries, and regulation of land and water use;
—coastal recreation as a source of wealth from the Sea;
—ocean resources development generally, for such States as Alaska and Hawaii;
—funding of State research and educational facilities.

Several States are considering unified approaches to programs and policies, by new legislative and administrative actions. Governors' advisory committes, inter-state groups, regional organizations, or citizens' groups have been established to deal with marine science affairs in California, Georgia, Massachusetts, Texas, Washington, Florida, New York, Hawaii, Virginia, the Great Lakes region, the Maine-New Hampshire area, and in other States and regions. Many of these committees and commissions reflect the same concern at a local level that led to the establishment of the Marine Sciences Council and Commission.

Federal and State Governments share many interests and responsibilities, especially relating to the Coastal Zone and the Federal Government intends to use existing Federal-State mechanisms for cooperative endeavors wherever possible. Information on State activities and capabilities now being collected by the Commission will be utilized by the Council for planning future programs in cooperation with the States and regional associations.

Similarly, many local goverments have pressing needs such as pollution management, waterfront renewal, and recreation—particularly in the large

metropolitan areas. Local community colleges can be participants in the Sea Grant Act. The role of local communities is expanding as the Nation becomes increasingly concerned with the problems of the cities.

Many of these problems and many metropolitan areas transcend state lines. Many shoreline or beach problems require a regional approach. Thus cooperation with regional mechanisms also must be studied because, in many instances, they may constitute the most appropriate device for considering marine science problems and providing the institutional mechanisms for solutions.

Within the past several years, a number of new professional societies or committees interested in marine science affairs have been established that aid in the traditional democratic processes of communication and national decision making. Specialized interest in marine science activities has led to the appointment of study or action committees in other professional and industrial associations. Several of their studies such as those by the National Security Industrial Association and by the State of California have been made available to the Marine Sciences Council and have been of great value in evaluating merits of alternative Federal policies.

Recent Financial Analyses

The future growth of marine programs will be heavily dependent on the availability of risk capital. Several investment and advisory firms recently have issued reports analyzing investment potential in oceanography. Many major diversified firms are committing funds to ocean projects, although published articles say that few have yet made substantial profits. These reports generally agree that the technological and systems approaches of aerospace are, to a large extent, applicable to oceanography.

Conclusion

Many Federal policies and programs can be carried out only in connection with States, industry, the academic community, and other institutions. The Council plans to identify areas where Federal assistance can be a catalyst. This assistance may take the form of legal measures, financial aids or support, or changes in Federal policies.

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Chapter XIV

THE NATION AND THE SEA: QUESTIONS FOR THE FUTURE

EACH of the preceding chapters describes a category of Federal activities which is related to the sea and which contributes to the attainment of the goals and aspirations of the Nation. For each of the categories, we have endeavored to focus the technical understanding we have today of the marine environment to produce sought-for benefits, then to formulate public policies and action programs to stimulate and guide many separate ocean activities. Each set of objectives thus depends on

—innovative engineering to transform scientific discovery to solutions of practical needs, effectively and economically;

—an institutional framework for public and private policies which will respond flexibly and promptly to new needs and opportunities.

The programs and appropriations reflect our planned endeavors during FY 1969. Individually, these programs support the missions of one or more Federal agencies; collectively, they respond to the needs of our entire society—a dynamic society with an expanding economy and a growing population. Many programs are continuations of past activities of proven benefit. Some emphasize new directions to take immediate advantage of opportunities for attaining reasonably certain results in the near term. Others stress planning of bold new programs which will keep pace with the changing character of science, technology, and society.

These programs reflect the best judgment that we can exercise today, based on foreseeable technological developments and on estimates of benefits and costs in a perspective of national priorities. While the course for the next 18 months—until the end of FY 1969—is reasonably clear, our attention now turns to an appraisal of marine sciences over the longer term, and to the broader perspective. We must now examine the more fundamental question: "What portion of the Nation's energy and wealth should be devoted to ocean endeavors, and how?" Precise quantitative answers may elude us, and our best estimate today will be slightly altered tomorrow. Nevertheless, the sea has served us and will continue to serve us, and our task is to inquire about the role of the oceans in contributing to the world of the future.

Five premises underpin any such projections:

First, science and technology that have been key ingredients of recent marine enterprises will continue and even increase in importance.

Second, the Federal Government—the primary sponsor of research and exploration—will continue to provide national leadership and financial support where necessary.

Third, exploitation of marine resources, as with resources on land, will be undertaken by competitive private enterprise.

Fourth, geographically localized problems in management of the marine environment of in-shore waters will require local solutions.

Fifth, gains from the ocean will be increasingly sought by other nations throughout the world.

These premises suggest that continued progress to extract ever-increasing benefits from the seas must continue to be generated by vigorous scientific research and exploration, by creative marine technology, and by evolving associated institutions, both public and private.

Marine science and technology are recognized predominantly as "means" rather than "ends." So indeed are the institutions that become the vehicles for action. Analysis of the future in marine sciences must therefore be cast in the context of even broader considerations—of fundamental national goals.

The need to enumerate such goals and appraise our progress becomes all the more compelling in a field as complex and differentiated as marine sciences.

Rapid progress can be made only by a society whose segments agree on major common purposes, and after they have reached agreement by a process of consensus.

To establish the future direction and pace of a truly national—and not just Federal—marine science program, we must examine and re-examine the

same key questions about both ends and means that were posed in the earlier chapters as a basis for contemporary decisions:

(1) How may increased utilization of the sea contribute to world order and peace?

(2) To what extent will world demand for resources require accelerated recovery of the living and nonliving resources of the sea, and how soon? How may marine resources contribute to the economies of developed and especially to developing nations?

(3) To what extent and in what ways do U.S. naval forces, maritime shipping, domestic fisheries, and oceanic research and exploration contribute to this Nation's broadest purposes and policies—toward national security, toward creation of wealth, and toward the economic and social well-being of all peoples?

(4) What leadership role should the Federal Government play in the development of marine resources and in their conservation, nationally and internationally?

(5) How may the Coastal Zone contribute best to our economic growth and to the joys of living? How can we develop rational plans for the optimal use and conservation of the coastal environment and its resources, to control pollution and erosion, and to choose among multiple and often conflicting uses through wise cooperative management?

(6) To what extent are future maritime developments dependent on intensified marine research, exploration, and engineering? What are the priority areas for oceanographic research and exploration? Who should undertake these activities and at what pace?

(7) What changes or innovations in national and international institutions and legal regimes are needed to foster public and private investments?

(8) What are the appropriate Federal, State, and local roles, and what is the optimum combination of public and private activities in developing resources and in managing the marine environment?

(9) How can we improve the present Federal structure to assure requisite leadership, meaningful priorities, and effective participation with science and industry?

These questions underlie the Nation's historical involvement in maritime affairs. They have been asked—and answered—in different ways at different stages of development of this Nation, and of the world itself. But yesterday's answers do not satisfy tomorrow's emerging needs and opportunities.

Problems induced by advanced technology will probably require solutions by technology. The implications may demand a change in our uncertainty about the importance of the sea.

The Marine Sciences Council is thus endeavoring to understand the stake that this Nation—and the world—has in the sea and to evolve a forward-looking and durable backdrop of policy—a possible strategy for use of the oceans.

In the months to come, the advisory Commission on Marine Science, Resources, and Engineering will conclude its independent analysis of these issues and report to the President, via the Council, and to the Congress on an adequate national program to meet present and future needs, including recommendations as to Federal organization. These questions and their appraisal furnish the agenda for study and for action during the forthcoming year.

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APPENDIX A

Table A–1—Total Federal Marine Science Program by Major Purpose and Organization (With Detail by Program)

(Millions of dollars)

Federal Marine Science Program by Major Purpose	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
1. International Cooperation and Collaboration	7.1	7.6	8.2
2. National Security	161.8	136.9	150.1
3. Fishery Development and Seafood Technology	38.1	41.2	42.7
4. Transportation	11.9	15.2	15.4
5. Development of the Coastal Zone [a]	21.4	28.7	28.6
6. Health	6.6	5.2	6.0
7. Non-living Resources	7.2	8.1	9.8
8. Oceanographic Research [b]	61.5	78.4	99.7
9. Education	4.0	7.2	7.9
10. Environmental Observation & Prediction & Services	24.4	24.5	26.5
11. Ocean Exploration, Mapping, Charting and Geodesy	77.4	74.5	92.1
12. General Purpose Ocean Engineering Development	14.8	18.2	26.8
13. National Data Centers	1.8	2.0	2.4
Total	438.0	447.7	516.2

[a] Includes Shore Development, Pollution Management, Recreation.
[b] Research beneficial to more than one of the headings above.

Detail of Major Purpose by Organization

(Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
1. International Cooperation and Collaboration	7.1	7.6	8.2
(a) State Department	(5.1)	(5.0)	(5.2)
(1) Contributions to international organizations for marine science program activities	3.0	3.0	3.1
(2) International fisheries commissions (U.S. share)	2.1	2.0	2.1
(b) Agency for International Development:			
(1) Marine food resources for developing nations	2.0	2.6	3.0
2. National Security [a]	161.8	136.9	150.1

See footnote at end of table.

Detail of Major Purpose by Organization—Continued

(Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
2. National Security—Continued			
(a) Department of Defense:			
(1) Problem oriented surveys for defense systems	23.2	19.3	29.4
(2) Marine science and technology in support of specific defense systems	32.0	31.2	37.7
(3) Undersea search, rescue, recovery, and man-in-the-sea	50.6	65.5	81.5
(4) Navy Instrumentation Center	0.8	1.3	1.3
(5) Capital investment for ship construction	52.6	18.7	0
(6) Marine science in support of "Safeguards" for the limited nuclear test ban treaty of 1963	2.6	0.8	0.2
3. Fishery Development and Sea Food Technology	38.1	41.2	42.7
(a) Department of the Interior:			
(1) Fishery resources assessment, development and management	28.4	30.3	29.5
(2) Technical and economic assistance to the commercial fishing industry	9.1	9.3	9.6
(3) Fish protein concentrate	.6	1.6	3.6
4. Transportation	11.9	15.2	15.4
(a) Department of Commerce	(7.9)	(10.4)	(7.6)
(1) Reduction of shipbuilding and port costs	0.2	1.6	0
(2) Reduction of ship operating costs	1.3	2.4	1.2
(3) Advanced ships and systems	2.1	2.0	[b] 1.7
(4) Ship design	0.7	0.8	0.9
(5) N.S. *Savannah*	3.6	3.6	3.8
(b) Department of Defense	(2.5)	(2.9)	(3.0)
(1) Channel and Harbor Development	2.5	2.9	3.0
(c) Department of Transportation	(1.5)	(1.9)	(4.8)
(1) Search and rescue	0.3	0.6	0.6
(2) Aids to navigation	0.6	0.7	0.9
(3) Merchant marine safety	0.3	0.3	1.0
(4) International ice patrol	0.3	0.3	0.4
(5) Pollution detection and control	0	0	1.9

See footnotes at end of table.

Detail of Major Purpose by Organization—Continued

(Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
5. Development and Conservation of the Coastal Zone	21.4	28.7	28.6
(a) Shore stabilization and protection	(1.5)	(1.5)	(1.7)
(1) Department of Defense:			
(a) Beach erosion control and hurricane storm surge protection	1.5	1.5	1.7
(b) Marine pollution management	(4.5)	(7.0)	(8.7)
(1) Department of Defense:			
(a) Pollution and flushing of bays, estuaries and the Great Lakes	0.4	1.7	2.4
(2) Department of the Interior:			
(a) Water quality enhancement	4.1	5.3	6.3
(c) Recreation and conservation	(15.4)	(20.2)	(18.2)
(1) Department of Defense:			
(a) Recreation beaches and small craft harbors	1.2	1.5	1.7
(2) Department of the Interior:			
(a) Planning for acquisition of marine based recreational areas	0.2	0.3	0.3
(b) Development of marine areas for recreation	8.3	9.6	8.8
(c) Conservation of marine locales, gamefish and wildlife	5.6	8.5	7.1
(3) Department of Transportation:			
(a) Search and rescue	0.1	0.3	0.3
6. Health	6.6	5.2	6.0
(a) Department of Health, Education, and Welfare:			
(1) Nutritional and health aspects of marine foods	1.0	1.2	1.3
(2) Marine bacterial toxins and pharmaceuticals	0.5	0.5	0.7
(3) Use of marine life in biomedical research	2.1	2.4	2.5
(4) Health problems related to marine pollution	0.9	1.1	1.1
(5) Capital investment	2.1	0.0	0.4

See footnotes at end of table.

Detail of Major Purpose by Organization—Continued

(Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
7. Non-Living Resources	7.2	8.1	9.8
(a) Department of the Interior:			
(1) Geologic investigations and resources appraisal	2.2	2.6	2.4
(2) Mining research	1.4	1.4	1.6
(3) Marine sources and interrelationships for supply of fresh water	2.9	3.4	4.1
(4) Leasing and management of mineral resources	0.7	0.7	1.7
8. Oceanographic Research	61.5	78.4	99.7
(a) Department of Defense	28.6	32.9	38.0
(b) Department of Commerce	2.3	3.5	4.2
(c) National Science Foundation	23.1	33.6	36.0
(d) Department of Transportation	1.9	2.7	15.7
(e) Smithsonian Institution	1.3	1.3	1.4
(f) Atomic Energy Commission	4.3	4.4	4.4
9. Education	4.0	7.2	7.9
(a) Department of Defense	0.9	1.2	1.3
(b) Department of Commerce	0.1	0.1	0.1
(c) Department of the Interior	0.2	0.2	0.2
(d) National Science Foundation	1.6	4.4	4.7
(e) Department of Health, Education, and Welfare	1.1	1.2	1.5
(f) Department of Transportation	0.1	0.1	0.1
10. Environmental Observation and Prediction and Services	24.4	24.5	26.5
(a) Department of Defense	11.7	10.7	11.3
(b) Department of Commerce	7.5	6.1	6.3
(c) Atomic Energy Commission	0.7	0.9	0.8
(d) Department of Transportation	4.4	5.5	6.8
(e) National Aeronautics and Space Administration	0.1	1.3	1.3

See footnotes at end of table.

Detail of Major Purpose by Organization—Continued

(Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
11. Ocean Exploration, Mapping, Charting, and Geodesy	77.4	74.5	92.1
(a) Department of Defense	60.2	56.2	72.3
(b) Department of Commerce	17.2	18.0	19.5
(c) National Aeronautics and Space Administration	0.0	0.3	0.3
12. General Purpose Ocean Engineering Development	14.8	18.2	26.8
(a) Deep ocean technology:			
(1) Department of Defense	8.2	10.7	14.9
(b) Nuclear power:			
(1) Atomic Energy Commission	6.3	7.4	6.6
(c) Data buoy systems:			
(1) Department of Transportation	0.3	0.1	5.3
13. National Data Centers	1.8	2.0	2.4
(a) National Oceanographic Data Center	1.4	1.5	1.8
(b) Smithsonian Oceanographic Sorting Center	0.3	0.3	0.3
(c) Great Lakes Data Center	0.1	0.2	0.2
(d) National Weather Records Center	0.0	0.1	0.1

[a] All Department of Defense funds except those pertaining to the civil works of the Army (Corps of Engineers) directly relate to National Security although they may appear in categories which relate to other national goals.

[b] In addition, Navy provides 1.4 million in matching funds for the Surface Effects Ship Program.

Table A–2—Total Federal Program by Department and Agency

(Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
Department of Defense	277.7	256.9	297.7
Department of the Interior	64.1	73.5	75.5
National Science Foundation	24.8	38.3	41.0
Department of Commerce	35.3	38.4	38.1
Department of Transportation	8.3	10.7	33.1
Atomic Energy Commission	11.3	12.7	11.8
Department of Health, Education, and Welfare	7.7	6.4	7.5
Department of State	5.1	5.0	5.2
Agency for International Development	2.0	2.6	3.0
Smithsonian Institution	1.6	1.6	1.7
National Aeronautics and Space Administration	.1	1.6	1.6
TOTAL AGENCY PROGRAMS	438.0	447.7	516.2
NATIONAL COUNCIL ON MARINE RESOURCES AND ENGINEERING DEVELOPMENT	(0.9)	(0.9)	(1.2)
COMMISSION ON MARINE SCIENCE, ENGINEERING, AND RESOURCES	(0.2)	(0.4)	(0.2)

Table A–3—Total Federal Program by Function and Agency

(Millions of dollars)

	Estimated FY 1967	Estimate FY 1968	President's budget FY 1969
1. Research and Development	209.8	249.5	281.6
(a) Research (basic and applied)	93.5	117.7	134.8
(b) Development of new equipment and technology	116.3	131.8	146.8
2. Investment	103.8	71.8	85.9
(a) Ships	68.9	22.5	16.9
(b) Major equipment	18.4	29.6	48.3
(c) Shore facilities	14.5	15.2	17.7
(d) Other	2.0	4.5	3.0
3. Operations	124.4	126.4	148.7
(a) Surveys	103.6	101.6	121.4
(b) Services	19.6	23.3	25.7
(c) Other operations	1.2	1.5	1.6
TOTAL	438.0	447.7	516.2

Detail by Function and Agency—Continued

(Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
RESEARCH AND DEVELOPMENT			
Total	209.8	249.5	281.6
1. Department of Defense	120.6	137.6	152.8
(a) Department of the Navy	(111.4)	(128.4)	(142.9)
(1) Research	28.6	32.9	38.0
Regular program	(25.7)	(28.4)	(32.0)
(Research ship operating costs)	((5.4))	((7.2))	((8.3))
Institutional development program	(2.9)	(4.5)	(6.0)
(2) Development of new equipment and technology	82.8	95.5	104.9
(Ship operating costs)	(7.2)	(7.9)	(10.0)
(b) Department of the Army	(6.6)	(8.4)	(9.7)
(1) Research	3.2	3.4	3.9
(2) Development of new equipment and technology	3.4	5.0	5.9
(c) Advanced Research Projects Agency	(2.6)	(0.8)	(0.2)
(1) Research	1.8	.8	0
(2) Development of new equipment and technology	0.8	0.1	0.2
2. Department of Commerce	11.6	15.7	13.7
(a) Environmental Science Services Administration.	(3.9)	(5.3)	(6.1)
(1) Research	2.6	3.5	4.5
(2) Development of new equipment and technology.	1.3	1.7	1.6
(b) Maritime Administration	(7.7)	(10.4)	(7.6)
(1) Research	2.4	5.6	2.9
(2) Development of new equipment and technology.	5.3	4.8	4.7
3. Department of the Interior	29.4	34.0	39.0
(a) Bureau of Commercial Fisheries	(18.7)	(21.0)	(25.6)
(1) Research	12.0	13.6	13.8
(Research ship operating costs)	(1.9)	(2.8)	(2.8)
(2) Development of new equipment and technology.	6.7	7.4	9.8
(b) Geological Survey	(3.0)	(3.3)	(3.2)
(1) Research	3.0	3.3	3.2
(2) (Research ship operation cost)	(0.2)	(0.2)	(0.2)

See footnotes at end of table.

Detail by Function and Agency—Continued

(Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
RESEARCH AND DEVELOPMENT—continued			
3. Department of the Interior—Continued			
(c) Office of Saline Water	(2. 1)	(2. 5)	(3. 1)
(1) Research	0. 6	0. 9	1. 0
(2) Development of new equipment and technology	1. 5	1. 6	2. 1
(d) Bureau of Sport Fisheries and Wildlife	(3. 1)	(3. 3)	(4. 2)
(1) Research	1. 4	1. 7	2. 5
(2) Development of new equipment and technology	1. 7	1. 6	1. 7
(e) Bureau of Mines	(0. 7)	(1. 0)	(1. 2)
(1) Research	0. 3	0. 4	0. 6
(Research ship operating costs)	(0. 1)	(0. 3)	(0. 4)
(2) Development of new equipment and technology	0. 4	0. 6	0. 6
(f) Federal Water Pollution Control Administration			
(1) Research	1. 8	2. 9	3. 7
4. National Science Foundation	22. 6	33. 2	38. 7
(1) Research	[a] 22. 6	[a] 33. 2	[a] 38. 7
(Research ship operating costs)	(8. 1)	(9. 1)	(10. 7)
5. Atomic Energy Commission	11. 3	12. 7	11. 8
(1) Research	5. 1	5. 4	5. 4
(Research ship operating costs)	(0. 3)	(0. 3)	(0. 3)
(2) Development of new equipment and technology	6. 2	7. 3	6. 4
6. Department of Health, Education, and Welfare	4. 7	5. 8	6. 4
(a) U.S. Public Health Service	(3. 6)	(4. 1)	(4. 3)
(1) Research	3. 6	4. 0	4. 2
(2) Development of new equipment and technology	0	0. 1	0. 1
(b) Food and Drug Administration	(0. 3)	(0. 4)	(0. 6)
(1) Research	. 3	. 4	. 6
(c) Office of Education	(1. 1)	(1. 2)	(1. 5)
(1) Research	1. 1	1. 2	1. 5

See footnotes at end of table.

Detail by Function and Agency—Continued

(Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
RESEARCH AND DEVELOPMENT—continued			
7. Department of Transportation	2.8	2.7	11.0
(a) U.S. Coast Guard:			
(1) Research	1.7	1.7	7.3
(Research ship operating costs)	(1.2)	(1.2)	(1.2)
(2) Development of new equipment and technology	1.1	1.0	3.7
8. Smithsonian Institution	1.3	1.3	1.4
(1) Research	1.3	1.3	1.4
9. State Department	5.1	5.0	5.2
(1) Development	5.1	5.0	5.2
10. National Aeronautics and Space Administration	0.1	1.6	1.6
(1) Research	0.1	1.6	1.6
INVESTMENT			
Total	103.8	71.8	85.9
1. Department of Defense	82.0	46.6	56.0
(a) Department of the Navy	(81.9)	(46.3)	(55.7)
(1) Ships (new construction of surface ships)	62.5	18.7	0
(2) Major equipment	16.4	25.9	45.6
(3) Shore facilities	3.0	1.7	10.1
(b) Department of the Army:			
(1) Shore facilities	(b)	0.3	0.3
2. Department of Commerce	3.1	1.9	1.2
(a) Environmental Science Services Administration	(2.9)	(1.9)	(0.9)
(1) Ships	1.5	0.0	0.0
(2) Shore facilities	0.0	0.2	0.0
(3) Major equipment	1.4	1.7	0.9
(b) Maritime Administration	(0.2)	(0.0)	(0.0)
(1) Shore facilities	0.2	0.0	0.0

See footnotes at end of table.

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Detail by Function and Agency—Continued

(Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
INVESTMENT—continued			
3. Department of the Interior	11.8	12.7	7.4
(a) Bureau of Commercial Fisheries	(4.9)	(3.3)	(1.7)
(1) Ships	3.5	1.6	0.0
(2) Shore facilities	1.4	1.7	1.7
(3) Major equipment	0.0	0.0	0.0
(b) Geological Survey	(0.3)	(0.4)	(0.4)
(1) Shore facilities	0.1	0.2	0.2
(2) Major equipment	0.2	0.2	0.2
(c) Bureau of Sport Fisheries and Wildlife	(0.5)	(0.8)	0.0
(1) Shore facilities	0.5	0.8	0.0
(d) Bureau of Mines	(0.7)	(0.4)	(0.4)
(1) Ships	0.5	0.2	0.2
(2) Shore facilities	0.1	0.1	0.1
(3) Major equipment	0.1	0.1	0.1
(e) Federal Water Pollution Control Administration	(0.2)	(0.2)	0.0
(1) Ships	0.0	0.0	0.0
(2) Shore facilities	0.0	0.2	0.0
(3) Major equipment	0.2	0.0	0.0
(f) Bureau of Outdoor Recreation	(4.4)	(6.9)	(3.9)
(1) Shore facilities	4.4	5.0	3.9
(2) Other	0.0	1.9	0.0
(g) National Park Service	(0.8)	(0.7)	(1.0)
(1) Shore facilities	0.8	0.7	1.0
4. National Science Foundation	2.0	4.8	2.0
(1) Ships	0.2	0.5	2.0
(2) Shore facilities	1.8	4.3	0.0
5. Department of Health, Education, and Welfare	2.1	0.0	0.4
(a) U.S. Public Health Service	(2.1)	(0.0)	(0.4)
(1) Shore facilities	2.1	0.0	0.4
6. Department of Transportation	0.8	3.2	16.2
(a) U.S. Coast Guard	(0.8)	(3.2)	(16.2)
(1) Ships	0.7	1.5	14.7
(2) Major equipment	0.1	1.7	1.5

See footnotes at end of table.

Detail by Function and Agency—Continued

(Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
INVESTMENT—continued			
7. Agency for International Development	2.0	2.6	3.0
(1) Other	2.0	2.6	3.0
OPERATIONS			
Total	124.4	126.4	148.7
1. Department of Defense	75.1	72.7	88.9
(a) Department of the Navy	(74.9)	(72.5)	(88.7)
(1) Surveys	71.2	68.1	83.7
(Survey ship operating costs)	(20.8)	(23.8)	(25.4)
(2) Services	2.8	3.2	3.7
(3) Other	0.9	1.2	1.3
(b) Department of the Army	(0.1)	(0.2)	(0.2)
(1) Services	0.1	0.2	0.2
2. Department of Commerce	20.6	20.8	23.5
(a) Environmental Science Services Administration	(20.6)	(20.8)	(23.5)
(1) Surveys	20.3	20.5	23.1
(Survey ship operating costs)	(6.6)	(6.6)	(8.0)
(2) Services	0.3	0.3	0.4
3. Department of the Interior	22.9	26.8	29.1
(a) Bureau of Commercial Fisheries	(14.5)	(16.8)	(17.3)
(1) Surveys	6.0	7.1	7.4
(Survey ship operating costs)	(1.2)	(1.4)	(1.4)
(2) Services	8.5	9.7	9.9
(Service ship operating costs)	(0.3)	(0.3)	(0.3)
(b) Geological Survey	(0.6)	(0.7)	(1.3)
(1) Services	0.6	0.7	1.3
(c) Bureau of Sport Fisheries and Wildlife	(3.0)	(3.5)	(3.7)
(1) Survey	0.4	0.4	0.5
(2) Services	2.3	2.8	2.9
(3) Other	0.3	0.3	0.3
(d) Federal Water Pollution Control Administration	(1.8)	(1.9)	(2.4)
(1) Surveys	1.0	0.8	0.8
(2) Services	0.8	1.1	1.6

See footnotes at end of table.

Detail by Function and Agency—Continued

(Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
OPERATIONS—continued			
3. Department of the Interior—Continued			
(e) Bureau of Land Management	(0.1)	(0.1)	(0.4)
(1) Services	0.1	0.1	0.4
(f) National Park Services	(2.9)	(3.8)	(4.0)
(1) Services	2.9	3.8	4.0
4. National Science Foundation	0.2	0.3	0.3
(1) Services	0.2	0.3	0.3
5. Atomic Energy Commission:			
(1) Services	[b]	[b]	[b]
6. Department of Health, Education, and Welfare:			
(a) U.S. Public Health Service	0.6	0.7	0.7
(1) Surveys	[b]	[b]	[b]
(2) Services	0.6	0.7	0.7
7. Department of Transportation:	4.7	4.8	5.9
(a) U.S. Coast Guard	(4.7)	(4.7)	(5.9)
(1) Surveys	4.7	4.7	5.8
(Survey ship operating costs)	(3.1)	(3.7)	(4.7)
(2) Services	[b]	0.1	0.1
8. Smithsonian Institution	0.3	0.3	0.3
(1) Services	0.3	0.3	0.3

[a] Includes Sea Grant Support.
[b] Less than $50,000.

Table A–4—Special Analyses: Continental Shelf, Great Lakes; Estuaries [a]

CONTINENTAL SHELF

(In Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
Smithsonian Institution	0.1	0.1	0.1
Department of Commerce	15.3	15.0	17.8
Atomic Energy Commission	2.0	2.0	2.0
Department of Transportation	0.5	0.5	1.9
National Science Foundation	0.5	0.5	1.0
Department of the Interior	29.8	34.6	37.1
1. Bureau of Commercial Fisheries	(21.0)	(22.5)	(23.4)
2. Geological Survey	(2.8)	(3.2)	(3.7)
3. Bureau of Sport Fisheries	(2.0)	(2.1)	(2.2)
4. Bureau of Mines	(1.2)	(2.5)	(2.5)
5. Bureau of Land Management	(0.1)	(0.1)	(0.4)
6. Office of Saline Water	(0.1)	(1.1)	(1.3)
7. National Park Service	(2.6)	(3.1)	(3.6)
Department of Defense	12.8	16.0	16.1
1. Department of the Army	(2.5)	(3.1)	(3.7)
2. Department of the Navy	(10.3)	(12.8)	(12.3)
Total	61.0	68.7	76.0

[a] These tables are designed to provide an indication of the level of effort in these areas.

GREAT LAKES

(In Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
Department of Commerce	0.1	0.1	0.1
Department of Transportation	0.0	0.0	0.1
State Department	1.0	1.0	1.1
National Science Foundation	.2	.2	.7
Department of the Interior	3.3	2.9	3.2
1. Bureau of Commerical Fisheries	(1.5)	(1.8)	(2.0)
2. Bureau of Sport Fisheries	(0.3)	(0.3)	(0.3)
3. National Park Service	(a)	(0.1)	(0.2)
4. Federal Water Pollution Control Administration	(1.5)	(0.7)	(0.7)
Department of Defense	2.5	3.6	4.5
1. Department of the Army	(2.4)	(3.5)	(4.4)
2. Department of the Navy	(0.1)	(0.1)	(0.1)
Total	7.1	7.8	9.7

[a] Less than $50,000.

ESTUARIES

(In Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
Smithsonian Institution	(a)	(a)	(a)
Department of Commerce	2.0	0.6	0.6
Atomic Energy Commission	0.3	0.3	0.3
Department of Transportation	(a)	(a)	(a)
National Science Foundation	0.5	0.6	1.7
Department of Health, Education, and Welfare [b]	3.5	1.4	1.9
Department of the Interior	19.9	23.4	25.2
1. Bureau of Commercial Fisheries	(8.5)	(9.3)	(9.6)
2. Geological Survey	(1.1)	(1.2)	(1.2)
3. Bureau of Sport Fisheries	(4.3)	(5.1)	(5.3)
4. Federal Water Pollution Control Administration	(3.8)	(5.0)	(6.1)
5. Office of Saline Water	(0.8)	(1.0)	(1.0)
6. National Park Service	(1.4)	(1.8)	(2.0)
Department of Defense	3.9	4.5	4.9
1. Department of the Army	(1.9)	(2.2)	(2.1)
2. Department of the Navy	(2.1)	(2.2)	(2.8)
Total	26.6	29.4	32.7

[a] Less than $50,000.

[b] Includes $2.1 million in construction in FY 1967 and $0.4 million in FY 1969.

Table A-5—Excess Foreign Currency Programs Summary

(In Millions of dollars)

	Estimated FY 1967	Estimated FY 1968	President's budget FY 1969
1. Fishery development and seafood technology:			
(a) Department of the Interior:			
(1) Fishery resources assessment, development, and management	0.3	0.2	0.2
2. Oceanographic research:			
(a) Department of Commerce (Environmental Science Services Administration)	(a)	(a)	(a)
(b) Smithsonian Institution:			
(1) Specimen Research	0.2	0.4	1.3
3. Data Centers:			
(a) Smithsonian Institution:			
(1) Service Operations	0.2	0.4	0.5

[a] Less than $50,000.

APPENDIX B

Federal Legislation Related to the Marine Sciences

(Enacted by the 89th and 90th Congresses)

Public Law 89–72 (July 9, 1965)—Federal Water Projects Recreation Act which provided uniform policies with respect to recreation and fish and wildlife benefits and costs of federal multi-purpose water resources projects.

Public Law 89–80 (July 21, 1965)—Water Resources Planning Act which provided for coordinated planning of water and related land resources, through the establishment of a water resources council and river basin commissions, and provided funds to the states to increase state participation in such planning.

Public Law 89–99 (July 30, 1965)—Exempted oceanographic research vessels from application of certain inspection laws.

Public Law 89–234 (October 2, 1965)—Water Quality Act of 1965 established the Federal Water Pollution Control Administration, provided grants for research and development, increased grants for construction of sewage treatment works, and required establishment of water quality criteria.

Public Law 89–298 (October 27, 1965)—Rivers and Harbors Act provided for study of water utilization and control of Chesapeake Bay and construction of a large scale model for this purpose.

Public Law 89–302 (October 30, 1965)—Authorized use by the Secretary of Interior of land at La Jolla, California, donated by the University of California, for a marine biological laboratory.

Public Law 89–454 (June 17, 1966)—Marine Resources and Engineering Development Act of 1966 established a national policy to advance marine sciences and created a cabinet level council and advisory commission.

Public Law 89–658 (October 14, 1966)—Established a contiguous fishing zone beyond the territorial sea of the United States.

Public Law 89–670 (October 15, 1966)—Provided for a Department of Transportation which includes the Coast Guard.

Public Law 89–688 (October 15, 1966)—National Sea Grant College and Programs Act of 1966 for authorized grants to institutions to operate programs of applied research, training and education, and information dissemination.

Public Law 89–701 (November 2, 1966)—Authorized practicable and economic means for the production of fish-protein concentrate.

Public Law 89–753 (November 3, 1966)—Clean Water Restoration Act of 1966 provided for Federal assistance to and cooperation with groups developing water quality control and pollution abatement programs and authorized a national estuarine pollution study.

Public Law 90–18 (May 19, 1967)—Provided for the participation of the Department of the Interior in the construction and operation of a large prototype desalting plant in southern California.

Public Law 90–30 (June 24, 1967)—Authorized appropriations for the saline water conversion program, to expand the program, and for other purposes.

Public Law 90–137 (November 14, 1967)—Amended the Foreign Assistance Act of 1961 to authorize, among others, a program to demonstrate the potential and encourage the use of fish and other protein concentrates as a practical means of reducing nutritional deficiencies in less developed countries and areas. The President was urged to use at least $2,500,000 of the total funds authorized by the Act for this particular program.

Public Law 90–205 (December 15, 1967)—Amended the Act of October 4, 1961, relating to the acquisition of wetlands for conservation of migratory waterfowl.

APPENDIX B—Federal Legislation Related to the Marine Sciences (Continued)

to extend for an additional eight years the period during which funds may be appropriated under that Act, and for other purposes.

Public Law 90–242 (January 2, 1968)—Amended the Marine Resources and Engineering Development Act of 1966 to extend the time for the Commission to render its report to January 9, 1969 and authorize the Council until June 30, 1969.

Sources: Federal Legislation for Oceanography (revised 1967), Library of Congress; Congressional Record; Digest of Public General Bills and Resolutions, Library of Congress.

APPENDIX C

Committees of the National Council on Marine Resources and Engineering Development

The Committees of the Council have the general responsibility of advising and assisting the Vice President and the Council in those fields of marine science and technology within their jurisdiction and involving more than one agency. Within this framework, they analyze current and future activities of the Federal agencies, identifying problems, deficiencies, needed reorientation or emphasis in the light of public needs. They undertake studies and submit recommendations to the Council, either as assigned or on their own initiative. Those activities for which one agency has sole responsibility do not fall within the Committees' jurisdiction.

Committee	Responsibility	Chairman
Committee on Marine Research, Education and Facilities.	Basic oceanographic research and engineering, and related vessels, equipment and facilities for Federal activity in marine research; manpower and specialized education in the marine sciences, including the Sea Grant Program.	Robert A. Frosch, Assistant Secretary of the Navy for Research and Development.
Committee on Ocean Exploration and Environmental Services.	Exploration, description, and prediction of the marine environment and the ships, buoys, satellites and other facilities required for these purposes; mapping, charting, and data management activities.	Robert M. White, Administrator, Environmental Science Services Administration.
Committee on Food from the Sea.	The broad, long-range program, adopted by the Council and the President in early 1967, to exploit the oceans in every reasonable way as a source of food, including the Fish Protein Concentrate Demonstration Program.	Herbert J. Waters, Assistant Administrator for War on Hunger, Agency for International Development.
Committee on Multiple Use of the Coastal Zone.	Environmental planning, conservation, and development; water pollution, erosion control, and shore development activities; channel and harbor development and redevelopment; marine ecology; and recreational development of marine areas.	Stanley A. Cain, Assistant Secretary of the Interior for Fish and Wildlife and Parks.
Committee on International Policy in the Marine Environment.[1]	U.S. foreign policy pertaining to the marine environment; international activities and initiatives pertaining to the marine environment, including cooperation by the United States with other nations and participation in international organizations and meetings.	Charles Bohlen, Deputy Under Secretary of State.

[1] Established by the Secretary of State, at the request of the Vice President, to serve the mutual interests of the Council and the Department of State.

APPENDIX D

Contracts Awarded by the National Council on Marine Resources and Engineering Development

Subject	Contractor	Amount
To collect and evaluate economic and industrial statistics on Marine Resources and Engineering Development.	Surveys & Research Corp., 1030 15th St. NW., Washington, D.C. 20005.	$6,400
A study of areas of legal conflict of immediate concern.	William L. Griffin, 1725 DeSales St. NW., Washington, D.C. 20036.	4,200
Report of achievements and problems of the International Indian Ocean Expedition and recommendations for the improvement of future expeditions.	Robert G. Snider, 112 West Foster Ave., State College, Pa.	6,000
A study of the international legal problems involved in the scientific exploration and investigation of the marine environment and its resources.	William T. Burke, Ohio State University, 1659 North High St., Columbus, Ohio 43210.	7,100
A study of the international legal problems involved in the management, use, development, recovery, and control of the mineral resources of the marine environment.	Louis Henkin, Columbia University School of Law, 435 West 116th St., New York, N.Y. 10027.	10,000
A study of international legal problems concerning living resources of the sea.	Paul W. Dodyk, Columbia University School of Law, 435 West 116th St., New York, N.Y. 10027.	7,425
A seminar on the liability aspects of activities in the marine environment.	American Trial Lawyers Association, Kraindler & Kraindler, 99 Park Ave., New York, N.Y. 10016.	1,000
A study of legal problems arising out of the management, use, development, recovery, and control of the marine resources along the coasts of the United States.	Albert Garretson, New York University School of Law, New York, N.Y.	20,000
A study of legal problems arising out of the management, use, development, and recovery of natural resources of the Great Lakes Area of the United States.	Board of Regents of the University of Wisconsin, Madison, Wis.	20,000
A study of requirements for and management of marine data systems.	System Development Corp., Santa Monica, Calif.	75,000
Nonmilitary needs for underwater technology.	Southwest Research Institute, San Antonio, Tex.	63,000

Contracts Awarded by the National Council on Marine Resources and Engineering Development—Continued

Subject	Contractor	Amount
A study of the utility of systems analysis for a U.S. fishery.	Litton Industries, Transportation Systems, Marine Technology, Inc., Beverly Hills, Calif. Subcontractor—Litton Industries Mellonics Division, Sunnyvale, Calif.	89, 373
Potential of aquaculture for providing food from the sea.	American Institute of Biological Science, 3900 Wisconsin Ave., Washington, D.C.	30, 756
The potential of observation of the oceans from spacecraft.	General Electric Missiles & Space Division, Valley Forge, Pa.	59, 433
Multiple use of the waters and coasts of the Chesapeake Bay.	Trident Engineering Associates, Annapolis, Md.	27, 254
Competing demands for land and water use in the Greater Seattle Harbor.	Management & Economics Research, Inc., Palo Alto, Calif.	35, 235
Economic potential of selected resources of the U.S. Continental Shelf and Slope.	Economic Associates, Inc., 1150 Connecticut Ave. NW., Washington, D.C.	55, 000
The relation of government programs to private investment enterprise in marine resources and engineering development (a cooperative study with the National Science Foundation).	National Planning Association, 1606 New Hampshire Ave. NW., Washington, D.C.	75, 057

APPENDIX E

Table E–1—Selected International Organizations Active in the Marine Sciences

UNITED NATIONS
- General
  - General Assembly
  - Economic and Social Council
  - U.N. Development Program
  - U.N. Children's Fund
  - International Atomic Energy Agency
  - Protein Advisory Group
  - International Court of Justice
  - International Law Commission
  - U.N. Conference on Trade and Development
- Specialized Agencies
  - Food and Agriculture Organization
  - UNESCO—Intergovernmental Oceanographic Commission
  - Intergovernmental Maritime Consultative Organization
  - World Meteorological Organization
  - World Health Organization
  - International Civil Aviation Organization
  - International Telecommunication Union
  - International Bank for Reconstruction and Development

INTERGOVERNMENTAL ORGANIZATIONS [1]
- International Hydrographic Bureau
- International Council for the Exploration of the Sea
- Permanent International Association of Navigation Congresses
- North Atlantic Treaty Organization
- Organization for Economic Cooperation and Development
- International Commission for the Scientific Exploration of the Mediterranean Sea
- Central Treaty Organization
- South Pacific Commission
- Indo-Pacific Fisheries Council
- Colombo Plan Council for Technical Cooperation in South and Southeast Asia
- Organization of American States
- Inter-American Development Bank
- Pan American Health Organization
- Pan American Institute of Geography and History

NONGOVERNMENTAL ORGANIZATIONS
- International Council of Scientific Unions
  - International Union of Geodesy and Geophysics
    - International Association for the Physical Sciences of the Ocean
  - International Union of Geological Sciences
    - Commission on Marine Geology
  - International Geographical Union
  - International Union of Biological Sciences
  - International Association of Biological Oceanography
  - Special Committee for the International Biological Program
  - Scientific Committee on Oceanic Research
  - Scientific Committee on Antarctic Research
  - International Geophysical Committee

See footnotes at end of table.

Table E–1—Selected International Organizations Active in the Marine Sciences—Continued

NONGOVERNMENTAL ORGANIZATIONS—Continued
- International Union for Conservation of Nature and Natural Resources
- Pacific Science Association
- Federation of Astronomical and Geophysical Services
  - Permanent Service for Mean Sea Level
- Scientific Committee on Water Research
- Mediterranean Association of Marine Biology and Oceanography
- Association of Island Marine Laboratories of the Caribbean
- Inter-American Geodetic Society
- Union of International Engineering Organizations
- Pan American Congress of Naval Engineering and Maritime Transport
- International Ship Structure Congress
- International Institute of Welding
- International Cable Protection Committee
- International Association of Lighthouse Authorities
- International Association of Ports and Harbors
- International Lifeboat Conference
- International Commission on Illumination
- International Maritime Radio Association
- International Radio Consultative Committee
- International Chamber of Commerce
- International Chamber of Shipping
- International Union of Marine Insurance
- International Maritime Committee
- International Gas Union
- Permanent Council of World Petroleum Congress
- Offshore Exploration Congress
- World Underwater Federation

[1] Fishery commissions are identified in Table E–5

Source: Department of State

Table E–2—United Nations Resolutions

A. Resolution Adopted by the General Assembly (on the report of the Second Committee—a/6533)

2172 (XXI) *Resources of the Sea*

The General Assembly,

Recognizing the need for a greater knowledge of the oceans and of the opportunities available for the utilization of their resources, living and mineral,

Realizing that the effective exploitation and development of these resources can raise the economic level of peoples throughout the world, and in particular of the developing countries,

Taking into account with appreciation the activities in the field of resources of the sea at present being undertaken by the United Nations, the United Nations Educational, Scientific and Cultural Organization and, in particular, its Inter-governmental Oceanographic Commission, the Food and Agriculture Organization of the United Nations and, in particular, its Committee on Fisheries, the World Meteorological Organization, the Advisory Committee on the Application of Science and Technology to Development, other intergovernmental organizations concerned, various governments, universities, scientific and technological institutions, and other interested organizations,

Table E–2—United Nations Resolutions—Continued

Considering the need to maximize international cooperative efforts for the further development of marine science and technology and to avoid duplication or overlapping of efforts in this field:

1. *Endorses* Economic and Social Council resolution 1112 (XL) of 7 March 1966 requesting the Secretary-General to make a survey of the present state of knowledge of the resources of the sea beyond the Continental Shelf, excluding fish, and of the techniques for exploiting these resources;

2. *Requests* the Secretary-General—in cooperation with the United Nations Educational, Scientific and Cultural Organization and, in particular, its Inter-governmental Oceanographic Commission, the Food and Agriculture Organization of the United Nations and, in particular, its Committee on Fisheries, the World Meteorological Organization, other intergovernmental organizations concerned, and the governments of interested member states, and utilizing, *inter alia*, such voluntary services as may be offered—to undertake, in addition to the survey requested by the Economic and Social Council, a comprehensive survey of activities in marine science and technology, including that relating to mineral resources development, undertaken by members of the United Nations family of organizations, various member states and intergovernmental organizations concerned, as well as by universities, scientific and technological institutes, and other interested organizations;

3. *Requests* the Secretary-General, in cooperation with the United Nations Educational, Scientific and Cultural Organization and, in particular, its Inter-governmental Oceanographic Commission and the Food and Agriculture Organization of the United Nations and, in particular, its Committee on Fisheries, and in the light of the above-mentioned comprehensive survey to formulate proposals for:

(*a*) Ensuring the most effective arrangements for an expanded program of international cooperation to assist in a better understanding of the marine environment through science and in the exploitation and development of marine resources, with due regard to the conservation of fish stocks;

(*b*) Initiating and strengthening marine education and training programs, bearing in mind the close interrelationship between marine and other sciences;

4. *Requests* the Secretary-General to set up a small group of experts to be selected, as far as possible, from the specialized agencies and intergovernmental organizations concerned, to assist him in the preparation of the comprehensive survey called for in paragraph 2 above and in the formulation of the proposals referred to in paragraph 3 above;

5. *Requests* that the survey and proposals prepared by the Secretary-General be submitted to the Advisory Committee on the Application of Science and Technology to Development for its comments;

6. *Requests* the Secretary-General to submit his survey and proposals, together with the comments of the Advisory Committee, to the General Assembly at its twenty-third session, through the Economic and Social Council.

1485th plenary meeting,
6 December 1966.

Table E–2—United Nations Resolutions—Continued

B. Resolution Adopted by the General Assembly (on the report of the First Committee—a/6964)

2340 (XXII)

Examination of the Question of the Reservation Exclusively for Peaceful Purposes of the Sea-Bed and the Ocean Floor, and the Subsoil Thereof, Underlying the High Seas Beyond the Limits of Present National Jurisdiction, and the Uses of Their Resources in the Interests of Mankind

The General Assembly,

Having considered the item "Examination of the question of the reservation exclusively for peaceful purposes of the seabed and the ocean floor, and the subsoil thereof, underlying the high seas beyond the limits of present national jurisdiction, and the uses of their resources in the interests of mankind",

Noting that developing technology is making the seabed and the ocean floor, and the subsoil thereof, accessible and exploitable for scientific, economic, military and other purposes,

Recognizing the common interest of mankind in the seabed and the ocean floor which constitute the major portion of the area of this planet,

Recognizing further that the exploration and use of the seabed and the ocean floor, and the subsoil thereof, as contemplated in the title of the item, should be conducted in accordance with the principles and purposes of the Charter of the United Nations, in the interest of maintaining international peace and security and for the benefit of all mankind,

Mindful of the provisions and practice of the law of the sea relating to this question,

Mindful also of the importance of preserving the seabed and the ocean floor, and the subsoil thereof, as contemplated in the title of the item, from actions and uses which might be detrimental to the common interests of mankind,

Desiring to foster greater international cooperation and coordination in the further peaceful exploration and use of the seabed and the ocean floor, and the subsoil thereof, as contemplated in the title of the item,

Recalling the past and continuing valuable work on questions relating to this matter carried out by the competent organs of the United Nations, the specialized agencies, the International Atomic Energy Agency and other intergovernmental organizations,

Recalling further that surveys are being prepared by the Secretary-General in response to General Assembly resolution 2172 (XXI) of 6 December 1966 and Economic and Social Council resolution 1112 (XL) of 7 March 1966,

1. *Decides* to establish an *ad hoc* Committee to study the peaceful uses of the seabed and the ocean floor beyond the limits of national jurisdiction composed of Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Ceylon, Chile, Czechoslovakia, Ecuador, El Salvador, France, Iceland, India, Italy, Japan, Kenya, Liberia, Libya, Malta, Norway, Pakistan, Peru, Poland, Rumania, Senegal, Somalia, Thailand, the Union of Soviet Socialist Republics, the United Arab Republic, the United Kingdom of Great Britain and Northern Ireland, the United Republic of Tanzania, the United States of America, and Yugoslavia, to study the scope and various aspects of this item;

Table E-2—United Nations Resolutions—Continued

2. *Requests* the *ad hoc* Committee, in cooperation with the Secretary-General, to prepare, for consideration by the General Assembly at its twenty-third session, a study which would include:

(a) a survey of the past and present activities of the United Nations, the specialized agencies, the International Atomic Energy Agency and other intergovernmental bodies with regard to the seabed and the ocean floor, and of existing international agreements concerning these areas;

(b) an account of the scientific, technical, economic, legal, and other aspects of this item;

(c) an indication regarding practical means to promote international cooperation in the exploration, conservation and use of the seabed and the ocean floor, and the subsoil thereof, as contemplated in the title of the item, and of their resources, having regard to the views expressed and suggestions put forward by Member States during the consideration of this item at the twenty-second session of the General Assembly;

3. *Requests* the Secretary-General:

(a) to transmit the text of this resolution to the Governments of all Member States in order to seek their views on the subject;

(b) to transmit to the *ad hoc* Committee the records of the First Committee relating to the discussion of this item;

(c) to render all appropriate assistance to the *ad hoc* Committee, including the submission thereto of the results of the studies being undertaken in pursuance of General Assembly resolution 2172 (XXI) and Economic and Social Council resolution 1112 (XL) and such documentation pertinent to this item as may be provided by the United Nations Educational, Scientific and Cultural Organization and its Inter-governmental Oceanographic Commission, the Inter-governmental Maritime Consultative Organization, the Food and Agriculture Organization of the United Nations, the World Meteorological Organization, the World Health Organization, the International Atomic Energy Agency and other intergovernmental bodies;

4. *Invites* the specialized agencies, the International Atomic Energy Agency, and other intergovernmental bodies to cooperate fully with the *ad hoc* Committee in the implementation of this resolution.

1639th plenary meeting,
18 December 1967.

Table E-3—Nations Which Have Ratified, Acceded to, or Consider Themselves Bound by the Geneva Conventions on the Law of the Sea [2]

	Convention on the high seas	Convention on the Continental Shelf	Convention on the territorial sea and contiguous zone	Convention on fishing and conservation of living resources of the high seas
Afghanistan	X			
Albania	X [1]	X		
Australia	X	X	X	X
Bulgaria	X [1]	X	X [1]	
Byelorussia	X [1]	X	X [1]	
Cambodia	X	X	X	X

See footnotes at end of table.

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Table E-3—Nations Which Have Ratified, Acceded to, or Consider Themselves Bound by the Geneva Conventions on the Law of the Sea [2]—Continued

	Convention on the high seas	Convention on the Continental Shelf	Convention on the territorial sea and contiguous zone	Convention on fishing and conservation of living resources of the high seas
Central African Republic	X			
Colombia		X		X
Czechoslovakia	X [1]	X	X [1]	
Denmark		X		
Dominican Republic	X	X	X	X
Finland	X	X	X	X
France		X [1]		
Guatemala	X	X		
Haiti	X	X	X	X
Hungary	X [1]		X [1]	
Indonesia	X [1]			
Israel	X	X	X	
Italy	X		X	
Jamaica	X	X	X	X
Madagascar	X	X	X [1]	X
Malawi	X	X	X	X
Malaya	X	X	X	X
Malta		X	X	
Mexico	X [1]	X	X [1]	X
Nepal	X			
Netherlands	X	X	X	X
New Zealand		X		
Nigeria	X		X	X
Poland	X [1]	X		
Portugal	X	X	X	X
Rumania	X [1]	X	X [1]	
Senegal	X	X	X	X
Sierra Leone	X		X	X
South Africa	X	X	X	X
Sweden		X		
Switzerland	X	X	X	X
Trinidad and Tobago	X		X	X
Uganda	X	X	X	X
Ukraine	X [1]	X	X [1]	
U.S.S.R.	X [1]	X	X [1]	
United Kingdom	X [1]	X	X [1]	X [1]
United States	X	X	X	X [1]
Upper Volta	X			X
Venezuela	X	X [1]	X [1]	X
Yugoslavia	X	X [1]	X	X

[1] With a reservation or declaration.

[2] Based on information available to the Department of State as of Dec. 8, 1967.

Table E-4—Breadth of Territorial Seas and Fishing Jurisdiction Claimed by Members of the United Nations

Country	Territorial sea	Fishing limits	Other
Albania	10 miles	12 miles	
Algeria	12 miles	----------	
Argentina	200 miles	----------	
Australia	3 miles	----------	
Barbados	----------	----------	
Belgium	3 miles	12 miles [1]	
Brazil	6 miles	12 miles	
Bulgaria	12 miles	----------	
Burma	do	----------	
Cambodia	5 miles	12 miles	Continental Shelf to 50 meters including sovereignty over superjacent waters.
Cameroun	18 miles	----------	
Canada	3 miles	12 miles	
Ceylon	6 miles	----------	Claims right to establish conservation zones within 100 nautical miles of the territorial sea.
Chile	50 kilometers.	200 miles	
China	3 miles	----------	
Colombia	6 miles	12 miles	
Congo (Brazzaville)	----------	----------	
Congo (Léopoldville)	----------	----------	
Costa Rica	3 miles	----------	
Cuba	3 miles	----------	
Cyprus	12 miles	----------	
Dahomey	3 miles	12 miles	
Denmark	do	do [1]	
Greenland	----------	do	
Faroe Islands	----------	do	
Dominican Republic	6 miles	----------	6-mile contiguous zone including fishing.
Ecuador	200 miles	----------	
El Salvador	200 miles	----------	
Ethiopia	12 miles	----------	
Federal Republic of Germany.	3 miles	12 miles [1]	
Finland	4 miles	----------	
France	3 miles	12 miles	
Gabon	3 miles	----------	
Gambia	3 miles	----------	
Ghana	12 miles	----------	Undefined protective areas may be proclaimed seaward of territorial sea, and up to 100 miles seaward of territorial sea may be proclaimed fishing conservation zone.

See footnote at end of table.

Table E-4—Breadth of Territorial Seas and Fishing Jurisdiction Claimed by Members of the United Nations—Continued

Country	Territorial sea	Fishing limits	Other
Greece	6 miles		
Guatemala	12 miles		
Guinea	130 miles		
Guyana			
Haiti	6 miles		
Honduras	12 miles		
Iceland	do	12 miles	
India	do	100 miles	
Indonesia	do		Archipelago theory.
Iran	do		
Iraq	do		
Ireland	3 miles	12 miles [1]	
Israel	6 miles		
Italy	do	12 miles [1]	
Ivory Coast	3 miles		
Jamaica	12 miles		
Japan	3 miles		
Jordan			
Kenya	3 miles		
Korea		20 to 200 miles.	Continental Shelf including sovereignty over superjacent waters.
Kuwait	12 miles		
Lebanon		6 miles	
Liberia	12 miles		
Libya	do		
Malagasy Republic	do		
Malaysia	3 miles		
Maldive Islands		6 miles	
Malta	3 miles		
Mauritania	12 miles	12 miles	
Mexico	9 miles	do	
Morocco	3 miles	do	Exception—6 miles for Strait of Gibraltar.
Muscat and Oman			
Netherlands	3 miles	12 miles [1]	
New Zealand	do	do	
Nicaragua	do	200 miles	Continental Shelf including sovereignty over superjacent waters.
Nigeria	12 miles		
Norway	4 miles	12 miles	

See footnote at end of table.

Table E-4—Breadth of Territorial Seas and Fishing Jurisdiction Claimed by Members of the United Nations—Continued

Country	Territorial sea	Fishing limits	Other
Pakistan	12 miles		Plus right to establish 100-mile conservation zones. Continental Shelf—including sovereignty over superjacent waters.
Panama	200 miles		
Peru	do	200 miles	
Philippines	Archipelago theory.		Waters within straight lines joining appropriate points of outermost islands of the archipelago are considered internal waters; waters between these baselines and the limits described in the Treaty of Paris, Dec. 10, 1898, the United States-Spain Treaty of Nov. 7, 1900, and U.S.-U.K. Treaty of Jan. 2, 1930, are considered to be the territorial sea.
Poland	3 miles		
Portugal	6 miles	12 miles [1]	
Romania	12 miles		
Saudi Arabia	12 miles		
Senegal	6 miles		
Sierra Leone	12 miles		
Singapore			
Somali Republic	6 miles		
South Africa	do	12 miles	
Spain	do	do [1]	
Sudan	12 miles		
Sweden	4 miles	12 miles [1]	
Syria	12 miles		Plus 6 miles necessary supervision zone.
Tanzania	do		
Thailand	do		
Togo	do		
Trinidad and Tobago	3 miles		
Tunisia	6 miles	12 miles	Territorial sea follows the 50-meter isobath for part of the coast (maximum 65 miles).

See footnote at end of table.

Table E–4—Breadth of Territorial Seas and Fishing Jurisdiction Claimed by Members of the United Nations—Continued

Country	Territorial sea	Fishing limits	Other
Turkey	6 miles	do	
Ukrainian S.S.R	12 miles		
U.S.S.R	do		
United Arab Republic	do		
United Kingdom	3 miles	12 miles [1]	
Colonies	do		
United States of America	do	12 miles	
Uruguay	6 miles	12 miles	
Venezuela	12 miles		
Vietnam		20 kilometers.	
Yemen	12 miles		
Yugoslavia	10 miles		

[1] Parties to the European Fisheries Convention which provides for the right to establish 3 miles exclusive fishing zone seaward of 3-mile territorial sea plus additional 6-mile fishing zone restricted to the convention nations.

Source: Information available to the National Council on Marine Resources and Engineering Development as of January 1, 1968.

Table E–5—Selected International Treaties in Marine Affairs To Which the United States Adheres

I. FISHERY COMMISSIONS
- Great Lakes Fishery Commission
- Inter-American Tropical Tuna Commission
- North Pacific Fur Seal Commission
- International North Pacific Fisheries Commission
- International Pacific Salmon Fisheries Commission
- International Pacific Halibut Commission
- International Commission for Northwest Atlantic Fisheries
- International Whaling Commission

II. MULTILATERAL MARITIME TREATIES
- Convention for Safety of Life at Sea
- Convention on Preventing Collisions at Sea
- Convention for Prevention of Pollution of the Sea by Oil
- International Load Line Convention
- Convention on Assistance and Salvage at Sea
- Convention on Bills of Lading
- Convention on Facilitation of International Maritime Traffic

Source: Department of State

Table E-6—Excerpts of Marine Affairs Interest From International Summit-Level Declarations and Speeches

I. Joint Statement from President Johnson of the U.S. and President Marcos of the Philippines, Washington, D.C. (September 15, 1966)

President Marcos set forth his vision of the Philippines future. He described the many frontiers that mankind faces—in space and in the ocean depths, * * *

The considerable economic loss suffered annually in the Far East from typhoons was discussed by the two Presidents, who agreed that the regional initiatives undertaken by ECAFE and WMO to improve technical capabilities for typhoon damage control deserved full support. President Johnson offered the services of a United States meteorological team to develop a joint program of typhoon damage control in the Philippine area in concert with regional planning, and President Marcos agreed to the desirability of such a program* * *

Finally, the two Presidents noted the cooperative programs already started between the Philippine National Science Development Board and the U.S. National Academy of Sciences, and agreed that these programs should be expanded so the private and public research efforts can be applied to the advance of knowledge about growing food on the land and in the sea in the tropics. The two Presidents noted the expanded efforts now underway by the U.S. Government in the field of oceanography, in which it was agreed that the Philippines would participate fully* * *

II. Joint Communiqué from President Johnson of the U.S. and Prime Minister Sato of Japan, Washington, D.C. (November 15, 1967)

The President and the Prime Minister, aware of the increasing importance of the oceans as a source of food for the world's growing population and as a source of minerals, have agreed to seek ways of greatly expanding United States-Japan cooperation in research and in development of technology for the utilization of mineral resources through the United States-Japan Conference on Development and Utilization of Natural Resources. For this purpose they have agreed that as part of the United States-Japan natural resources program, there should be prepared a report and recommendations of the two Governments looking to cooperation between the two countries in this field.

III. Address by President Johnson at the Inter-American Summit, Punta del Este, Uruguay (April 13, 1967)

"* * * We are prepared to join with the Latin American nations in: * * * Developing a regional program of marine science and technology. * * * We are also prepared to set up in Latin America a demonstration center in the field of fish protein concentrate. We believe that this essential ingredient of a balanced diet can be provided at a much lower cost than in the past. * * *"

APPENDIX F

Laboratories and Institutions [1] Engaged in Marine Science Research

ALABAMA:	
Federal	Gulf Coast Marine Health Sciences Laboratory (PHS) (Dauphin Island)
	Southeastern Fish Cultural Laboratory (BSF & W) (Marion)
State	Alabama Fish and Game Commission (Dauphin Island)
Academic	Alabama Marine Resources Laboratory (Dauphin Island)
	University of Alabama (University)
Private	Southern Research Institute (Birmingham)
ALASKA:	
Federal	Biological Laboratory (BCF) (Auke Bay)
	Exploratory Fishing and Gear Research Base (BCF) (Juneau)
	Naval Arctic Research Laboratory (Point Barrow)
State	Alaska Department of Fisheries (Juneau)
	Alaska Department of Fish and Game (Kodiak)
Academic	University of Alaska (College)
CALIFORNIA:	
Federal	Biological Field Station (BCF) (Tiburon)
	Biological Laboratory (BCF) (Stanford; La Jolla; Sabine Island; San Diego)
	California Cooperative Fisheries Investigations (BCF) (La Jolla)
	California Current Research Laboratory (BCF) (La Jolla)
	Fishery Oceanography Center (BCF) (Terminal Island)
	Ichthyological Field Station (BCF) (Stanford)
	Inter-American Tropical Tuna Commission (International) (La Jolla)
	Marine Minerals Technology Center (BuMines) (Tiburon)
	Naval Civil Engineering Laboratory (Port Hueneme)
	Naval Command Control Communications Center Laboratory (San Diego)
	Naval Missile Center (Point Mugu)
	Naval Postgraduate School (Monterey)
	Naval Radiological Defense Laboratory (San Francisco)
	Naval Undersea Warfare Center (Pasadena; San Diego)
	Tiburon Marine Laboratory (BSF & W) (Tiburon)
	Tuna Research Laboratory (BCF) (La Jolla)
State	Marineland of the Pacific (Portuguese Bend)
	San Diego Museum of Natural History (San Diego)
	State Department of Fish and Game (San Pedro; Pacific Grove; Menlo Park; Eureka)
Academic	Bodega Marine Laboratory (University of California) (Bodega Head)
	Bolinas Marine Station (College of Marin) (Bolinas)

See footnote at end of table.

Laboratories and Institutions[1] Engaged in Marine Science Research—Con.

California—Continued	
Academic	California Institute of Technology (Pasadena)
	California State College at Long Beach (Long Beach)
	Catalina Marine Biological Laboratory (Santa Catalina Island).
	Humboldt State College (Arcata)
	Mendocino Biological Field Station (Pacific Union College) (Albion)
	Moss Landing Marine Laboratories (Moss Landing)
	Pomona College (Claremont)
	San Diego State College (San Diego)
	San Jose State College (San Jose)
	Santa Barbara Marine Station (University of California) (Santa Barbara)
	Scripps Institution of Oceanography (La Jolla)
	Stanford University (Stanford; Pacific Grove)
	University of California (San Diego; La Jolla; Berkeley)
	University of the Pacific (Dillon Beach)
	University of Southern California (Los Angeles)
Private	Aquatic Research Institute (Stockton)
	Beaudette Foundation (Moss Landing)
	California Academy of Sciences (San Francisco)
	Kerckhoff Marine Laboratory (Corona del Mar)
	Mission Bay Research Foundation (La Jolla)
	Stanford Research Institute (Palo Alto)
Connecticut:	
Federal	Biological Laboratory (BCF) (Milford)
	Navy Underwater Sound Laboratory (New London).
Academic	University of Bridgeport (Bridgeport)
	University of Connecticut (Storrs)
	Yale University (Bingham Oceanographic Laboratory) (New Haven)
Delaware:	
Academic	University of Delaware (Newark)
Private	Bayside Laboratory (Lewes Ferry)
District of Columbia:	
Federal	Biological Field Station (BCF)
	Ichthyological Laboratories (BCF)
	National Oceanographic Data Center
	Smithsonian Oceanographic Sorting Center
	Smithsonian Museum of Natural History
	Army Coastal Engineering Research Center
	Coast Guard Oceanographic Unit (DOT)
	Naval Research Laboratory
Academic	Catholic University of America
	Department of Agriculture Graduate School

See footnote at end of table.

Laboratories and Institutions[1] Engaged in Marine Science Research—Con.

FLORIDA:	
Federal	Biological Laboratory (BCF) (Gulf Breeze)
	Biological Station (BCF) (St. Petersburg Beach)
	Eastern Gulf Marine Laboratory (BSF&W) (Panama City)
	Exploratory Fishing and Gear Research Station (BCF) (Miami; Panama City)
	Atlantic Oceanographic Laboratories (ESSA) (Miami)
	National Hurricane Research Laboratory (ESSA) (Miami)
	Sea Air Interaction Laboratory (ESSA) (Miami)
	Tropical Atlantic Biological Laboratory (BCF) (Miami)
	Naval Research Laboratory (Underwater Sound Reference Division) (Orlando)
	Naval R & D Center (ex-Mine Defense Laboratory) (Panama City)
State	Florida State Board of Conservation (St. Petersburg)
Academic	Florida Atlantic University (Boca Raton)
	Florida Institute of Oceanology (Melbourne)
	Florida Presbyterian College (St. Petersburg)
	Florida State University (Tallahassee)
	Nova University (Fort Lauderdale)
	University of Florida (Gainesville; Cedar Key)
	University of Miami (Miami)
	University of South Florida (Tampa)
	University of West Florida (Pensacola)
Private	Battelle Memorial Institute (Daytona Beach)
	Mote Marine Laboratory (Cape Haze Laboratory) (Sarasota)
GEORGIA:	
Federal	Biological Laboratory (BCF) (Brunswick)
	South Atlantic Exploratory Fishing and Gear Research Station (BCF) (St. Simons Island)
Academic	University of Georgia Marine Institute (Sapelo Island)
HAWAII:	
Federal	Biological Laboratory (BCF) (Honolulu)
	Joint Tsunami Research Effort (ESSA) (Honolulu)
State	Division of Fish and Game (Honolulu)
Academic	University of Hawaii (Honolulu)
Private	Oceanic Institute (Oahu)
ILLINOIS:	
Academic	Illinois State University (De Kalb)
	Northwestern University (Evanston)
	University of Chicago (Chicago)
	University of Illinois (Urbana)
INDIANA:	
Academic	University of Notre Dame (Notre Dame)

See footnote at end of table.

Laboratories and Institutions[1] Engaged in Marine Science Research—Con.

LOUISIANA:	
Federal	Technical Laboratories (BCF) (New Orleans)
State	Grand Terre Island Laboratory (New Orleans)
	Louisiana Wildlife and Fisheries Commission (Grand Chenier)
Academic	Louisiana State University (Baton Rouge)
	University of Southwestern Louisiana (Lafayette)
MAINE	
Federal	Biological Laboratory (BCF) (Boothbay Harbor)
State	Department of Inland Fisheries and Game (Bangor)
	Department of Sea and Shore Fisheries (Boothbay Harbor)
Academic	University of Maine Marine Station (Walpole)
MARYLAND:	
Federal	Biological Laboratory (BCF) (Oxford)
	Coast and Geodetic Survey (ESSA) (Rockville)
	Naval Oceanographic Office (Suitland)
	Naval Ordnance Laboratory (Silver Spring)
	Naval R & D Center (ex-David Taylor Model Basin) (Carderock).
	Naval R & D Center (ex-Naval Marine Engineering Laboratory) (Annapolis)
Academic	Chesapeake Bay Institute (Johns Hopkins University) (Baltimore).
	Chesapeake Biological Laboratory (University of Maryland) (Solomons).
MASSACHUSETTS:	
Federal	Biological Laboratory (BCF) (Woods Hole)
	Exploratory Fishing and Gear Research Base (BCF) (Gloucester).
	International Ice Patrol (U.S. Coast Guard) (Woods Hole)
State	Massachusetts Division of Fisheries and Game (Boston)
Academic	Massachusetts Institute of Technology (Cambridge)
	Museum of Comparative Zoology (Harvard University) (Cambridge).
	Northeastern University (Boston)
	Southern Mass. Technological Institution (Cambridge)
	Tufts University (Medford)
	University of Massachusetts (Amherst)
Private	William F. Clapp Laboratory (Duxbury)
	Woods Hole Oceanographic Institution (Woods Hole)
MICHIGAN:	
Federal	Biological Laboratory (BCF) (Ann Arbor)
	Exploratory Fishing and Gear Research Laboratory (BCF) (Ann Arbor).
	Great Lakes Research Group (ESSA) (Detroit)
	Lake Survey (Army Corps of Engineers) (Detroit)
State	Department of Conservation (Lansing)
Academic	Michigan State University (East Lansing)
	University of Michigan (Ann Arbor)

See footnote at end of table.

Laboratories and Institutions[1] Engaged in Marine Science Research—Con.

MINNESOTA:	
Federal	Great Lakes Water Laboratory (FWPCA) (Duluth)
State	State Department of Conservation (St. Paul)
Academic	University of Minnesota (Minneapolis)
MISSISSIPPI:	
Federal	Exploratory Fishing and Gear Research Base (BCF) (Pascagoula).
	Waterways Experiment Station (Corps of Engineers) (Vicksburg).
Academic	Gulf Coast Research Laboratory (Ocean Springs)
NEW HAMPSHIRE:	
State	Fish and Game Department (Concord)
Academic	University of New Hampshire (Durham)
NEW JERSEY:	
Federal	Sandy Hook Marine Laboratory (BSF & W) (Highlands)
State	Division of Fish and Game (Trenton)
	New Jersey Oyster Research Laboratories (New Brunswick; Bivalve; Monmouth Beach; Cape May Courthouse)
Academic	Princeton University (Princeton)
	Rutgers—The State University (New Brunswick)
	Stevens Institute of Technology (Hoboken)
NEW YORK:	
Federal	Naval Applied Science Laboratory (Brooklyn)
Academic	City University of New York (New York City)
	Cornell University (Ithaca)
	Hudson Laboratories (Columbia University) (Dobbs Ferry)
	Lamont Geological Observatory (Columbia University) (Palisades)
	Long Island University (Brookville, Long Island)
	New York University (Bronx)
	Rensselaer Polytechnic Institute (Troy)
	Southampton College (NYU) (Southampton)
	State University of New York (Buffalo)
	Webb Institute of Naval Architecture (Glen Cove)
Private	American Museum of Natural History (New York City)
	Institute of Oceanography and Marine Biology (Oyster Bay, Long Island).
	New York Zoological Society (Brooklyn)
NORTH CAROLINA:	
Federal	Biological Laboratory (BCF) (Beaufort)
	Radiobiological Laboratory (BCF) (Beaufort)
State	Department of Water Resources (Raleigh)
Academic	Duke University (Beaufort; Durham)
	North Carolina State University (Raleigh)
	University of North Carolina (Morehead City)
OHIO:	
Academic	Ohio State University (Columbus)
Private	Battelle Memorial Institute (Columbus)

See footnote at end of table.

Laboratories and Institutions[1] Engaged in Marine Science Research—Con.

OREGON:	
Federal	Water Pollution Control Laboratory (FWPCA) (Corvallis)
State	Oregon Fish Commission Laboratories (Clackamas; Astoria; Newport; Charleston; Oakridge).
Academic	Oregon State University (Corvallis; Newport)
	University of Oregon (Charleston; Portland)
PENNSYLVANIA:	
Federal	Naval Air Development Center (Johnsville)
	Naval Air Engineering Center (Philadelphia)
Academic	Lehigh University (Bethlehem)
	Pennsylvania State University (University Park)
	University of Pittsburgh (Pittsburgh)
Private	Philadelphia Academy of Sciences (Philadelphia)
RHODE ISLAND:	
Federal	Narragansett Marine Gamefish Laboratory (BSF & W) (Kingston)
	Northeast Marine Health Sciences Laboratory (PHS) (Kingston)
	Naval Underwater Weapons Research and Engineering Station (Newport)
Academic	University of Rhode Island (Kingston)
SOUTH CAROLINA:	
State	Bears Bluff Laboratories (Wadmalaw Island)
Academic	College of Charleston (Charleston)
Private	Fort Johnson Marine Biological Laboratory (Charleston)
TEXAS:	
Federal	Biological Laboratory (BCF) (Galveston)
State	Texas Fish and Game Commission (Austin)
	Texas Parks and Wildlife Department (Rockport)
Academic	Texas A&M University (Galveston; College Station)
	University of Texas (Port Aransas)
	University of Houston (Houston)
Private	Southwest Research Institute (San Antonio)
VIRGINIA:	
Federal	Land-Sea Interaction Laboratory (ESSA) (Norfolk)
	Norfolk Ship Base (Navy) (Norfolk)
	Naval Weapons Laboratory (Yorktown)
State	Eastern Shore Laboratory (Wachapreague)
Academic	College of William and Mary (Williamsburg)
	Old Dominion College (Norfolk)
	Virginia Institute of Marine Science (Gloucester Point)

See footnote at end of table.

Laboratories and Institutions[1] Engaged in Marine Science Research—Con.

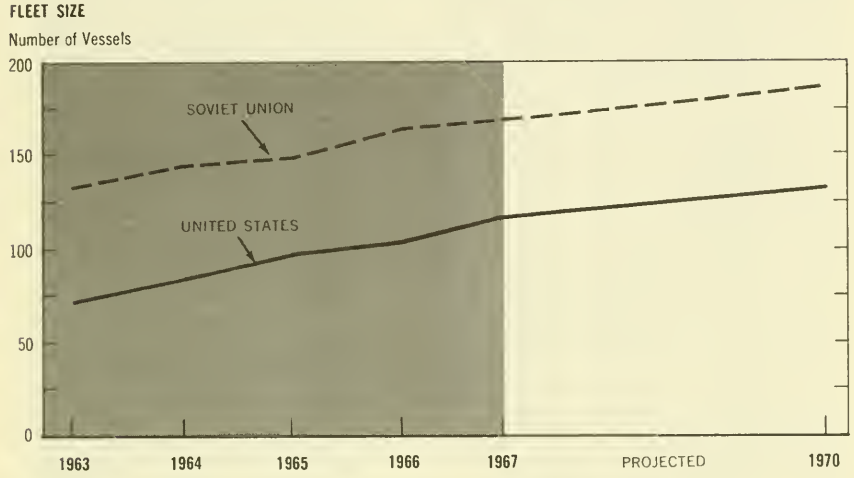
WASHINGTON:	
Federal	Biological Laboratory (BCF) (Seattle)
	Exploratory Fishing and Gear Research Base (BCF) (Seattle)
	International Pacific Halibut Commission (Seattle)
	Joint Oceanographic Research Group (ESSA) (Seattle)
	Marine Mammal Biological Laboratory (BCF) (Seattle)
	Northwest Research Laboratory (FWPCA) (Richland)
	Pacific Oceanographic Laboratories (ESSA) (Seattle)
	Salmon Culture Laboratory (BSF & W) (Longview)
	Northwest Marine Health Sciences Laboratory (PHS)(Gig Harbor)
State	Department of Fisheries Research Laboratories (Olympia; Brinnon; Aberdeen; Vancouver; Seattle; Ocean Park)
Academic	Seattle Pacific College (Seattle)
	University of Washington (Seattle)
	Walla Walla College (Anacortes)
	Western Washington State College (Bellingham)
Private	Battelle-Northwest (Pacific Northwest Laboratory) (Richland)
WISCONSIN:	
Academic	University of Wisconsin (Madison)
OTHER U.S.:	
Federal	Smithsonian Tropical Research Institute (Canal Zone)
Academic	University of Puerto Rico (Mayaguez)
FOREIGN:	
Federal	Atlantic Underwater Test and Evaluation Center (AUTEC) (Bahamas)
	Navy Underwater Sound Laboratory Research Detachment (Tudor Hill, Bermuda)
State	Vermillion Sea Field Station (Baja California)
Academic	Lamont Geophysical Field Station (Columbia University) (St. David's, Bermuda)
	Marine Laboratory (Puerto Penasco, Mexico)
Private	Bermuda Biological Station (St. George's West, Bermuda)
	Lerner Marine Laboratory (Bimini, BWI)

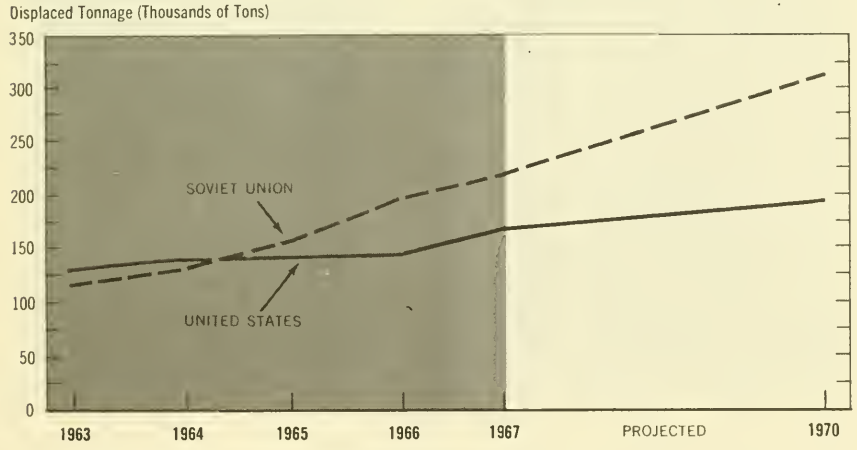
[1] Industrial research centers have been excluded.

Source: *Hydrospace Buyers' Guide*, Data Publications; *Oceanography Information Sources*, National Academy of Sciences; *Information Resources in the United States—Water*, Library of Congress; National Referral Center, Library of Congress; Committee on Marine Research, Education, and Facilities; miscellaneous.

APPENDIX G

G-1– Estimated Growth of the Oceanographic[1] Fleets of the United States and the Soviet Union





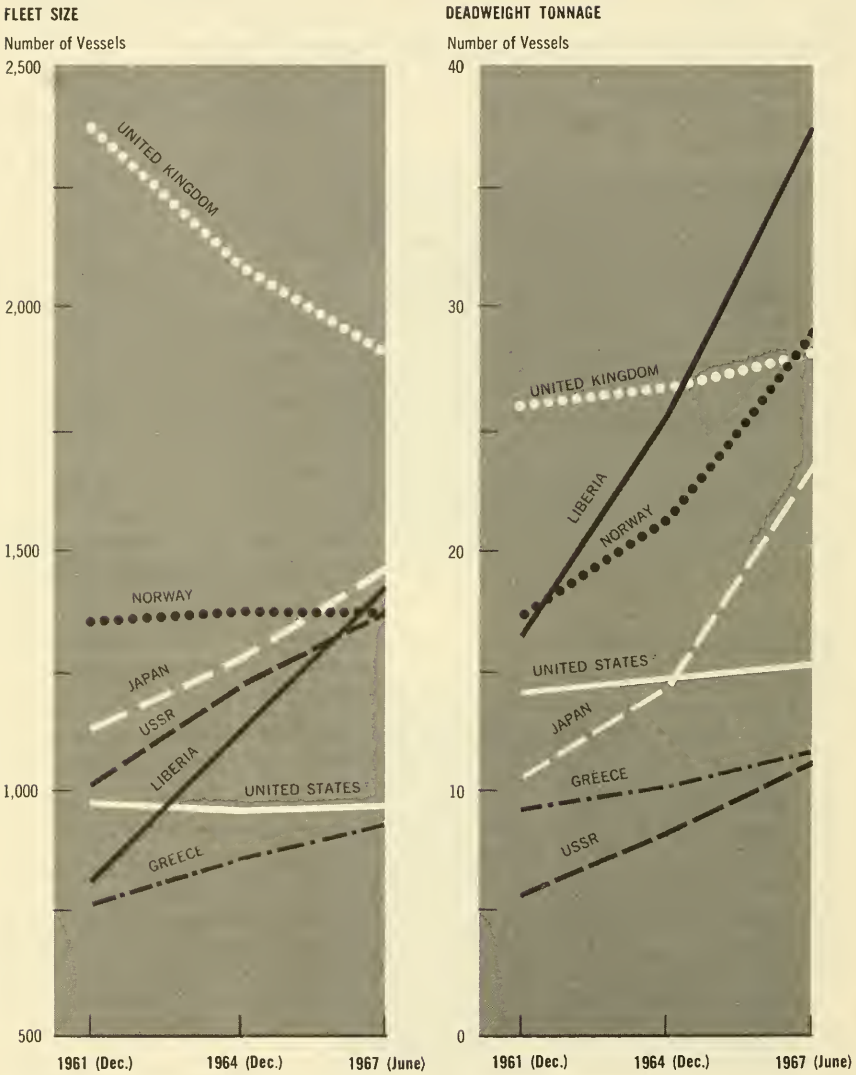
[1] Includes fishery research vessels, as well as oceanographic ships, that spend significant time making oceanographic collections.

[2] Excludes Coast Guard vessels except for the International Ice Patrol vessels.

NOTE: Soviet totals, unlike those for the U.S., do not include ship decommissionings and other losses from the fleet and therefore may be slightly higher than actual.

Sources: National Oceanographic Data Center; Committee on Marine Research, Education and Facilities; Miscellaneous.

G-2– Merchant Fleets[1] of the World

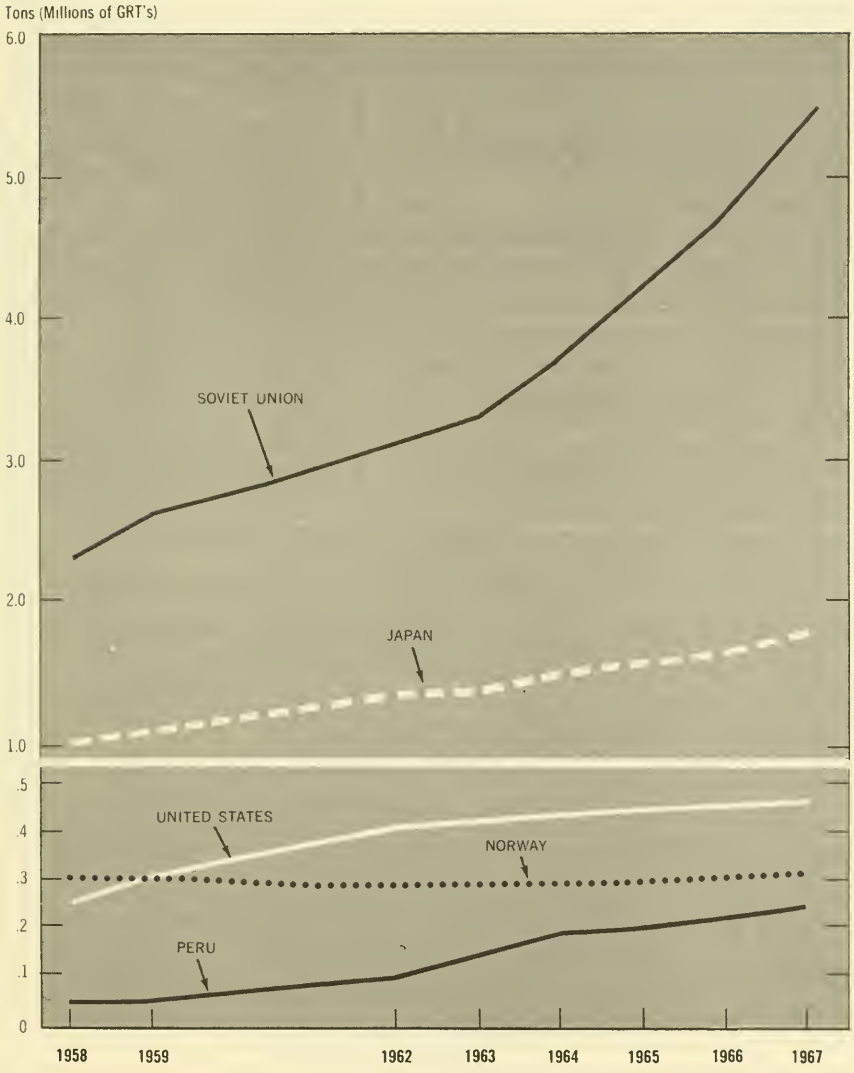


[1] Oceangoing steam and motor ships of 1000 gross tons or more. Excludes ships operating exclusively on inland waterways and special ships such as channel ships, icebreakers, military ships, etc.

[2] Only privately-owned U.S. ships are included. U.S. government ships, excluding the reserve fleet, rose from 64 vessels in 1961 to 201 vessels in 1967 but this largely reflects activation of reserve ships for war duty.

Sources: Merchant Fleets of the World, 1961, 1964, 1967, Maritime Administration, U.S. Department of Commerce

G-3— Estimated Growth in Tonnage of the High Seas Fishing Fleets' of Selected Nations



' Ships larger than 5 net tons operating in the open seas and major inland seas such as the Caspian and Black Seas and the Great Lakes.

NOTE: Tonnage scale changes for Japan and Soviet Union.

Sources: Bureau of Commercial Fisheries; Bulletin of Fishery Statistics, No. 14, Food and Agricultural Organization of the United Nations, 1966; Embassy of Peru; Miscellaneous.

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APPENDIX H

Table H-1—Volume of Cargo Handled in Waterborne Commerce at Thirty Selected U.S. Ocean Ports, 1955 and 1965

Port	1955		1965	
	Ranking	Total Tons [1]	Ranking	Total Tons [1]
New York, N.Y	1	148, 849	1	153, 855
New Orleans, La	4	47, 083	2	88, 877
Houston, Tex	5	47, 038	3	59, 832
Philadelphia, Pa	3	48, 493	4	47, 735
Duluth, Minn.; Superior, Wis	2	68, 312	5	46, 177
Chicago, Ill	7	38, 969	6	45, 973
Toledo, Ohio	9	35, 725	7	45, 016
Baltimore, Md	6	45, 824	8	44, 267
Norfolk, Va	8	35, 930	9	40, 017
Detroit, Mich	10	26, 498	10	32, 262
Baton Rouge, La	20	16, 490	11	31, 659
Beaumont, Tex	12	22, 863	12	31, 566
Port Arthur, Tex	13	21, 578	13	25, 414
Cleveland, Ohio	14	20, 427	14	21, 960
Mobile, Ala	23	15, 083	15	21, 837
Los Angeles, Calif	18	19, 264	16	21, 000
Corpus Christi, Tex	21	15, 574	17	20, 283
Boston, Mass	19	19, 052	18	19, 855
Tampa, Fla	30	10, 656	19	19, 829
Indiana Harbor, Ind	15	20, 675	20	18, 567
Portland, Maine	25	14, 219	21	18, 463
Paulsboro, N.J	27	13, 151	22	18, 460
Texas City, Tex	24	14, 310	23	18, 155
Buffalo, N.Y	11	22, 962	24	17, 849
Marcus Hook, Pa	17	19, 882	25	17, 457
Portland, Oreg	28	12, 593	26	16, 726
Richmond, Calif	26	14, 032	27	15, 450
Seattle, Wash	29	12, 481	28	14, 748
Lake Charles, La	22	15, 395	29	14, 470
Newport News, Va	16	20, 616	30	14, 235

[1] In thousands of tons of 2,000 pounds.

Source: Waterborne Commerce of the United States, 1955, 1965, U.S. Army Corps of Engineers.

Table H–2—Coastal Channel and Harbor New Work Projects [1] (Underway as of December 1967) [2]

Location	Project	Total Federal cost (millions of dollars)
ATLANTIC COAST		(334. 2)
New Hampshire	Portsmouth Harbor and Piscatagua River	4. 3
Massachusetts	Boston Harbor	2. 6
	Plymouth Harbor	1. 9
	Provincetown Harbor	2. 8
	Weymouth-Fore and Town River	14. 9
Rhode Island	Providence River and Harbor	17. 0
New York	Flushing Bay and Creek	2. 1
	Lake Montauk Harbor	0. 9
	Little Neck Bay	2. 0
	New York Harbor Anchorages	45. 7
New Jersey	Delaware River, Philadelphia to sea	29. 0
	Newark Bay, Hackensack, and Passaic River	15. 8
Delaware	IWW Delaware River to Chesapeake Bay, C & D Canal.	100. 0
Maryland	Baltimore Harbor and channels	22. 9
Virginia	Hampton Roads	29. 9
North Carolina	AIWW Masonboro Inlet	2. 8
	Wilmington Harbor, 38- and 40-foot channels	6. 0
Georgia	Savannah Harbor, 40-foot project	8. 7
	Savannah Harbor, sediment basin	7. 4
Florida	Canaveral Harbor	8. 7
	Jacksonville Harbor	8. 8
GULF COAST		(241. 5)
Florida	Apalachicola River Channel	4. 6
	East Pass Channel	0. 9
	Gulf County Canal	0. 5
	Ponce DeLeon Inlet	1. 2
Alabama	Bayou LaBatre	0. 3
	Perdido Pass Channel	0. 7
Mississippi	Biloxi Harbor	0. 8
Louisiana	Bayou LaFourche and LaFourche Jump	5. 7
	Freshwater Bayou	9. 4
	Mississippi River, Baton Rouge to Gulf	8. 4
	Mississippi River, Gulf outlet	163. 0
Texas	GIWW—Chocolate Bayou	1. 4
	Sabine-Neches Waterway	27. 4
	Wallisville Reservoir	17. 2

See footnotes at end of table.

Table H-2—Coastal Channel and Harbor New Work Projects [1] (Underway as of December 1967) [2]—Continued

Location	Project	Total Federal cost (millions of dollars)
Pacific Coast		(113. 9)
California	Dana Point Harbor	4. 6
	Oakland Harbor	8. 5
	Sacramento River, deep water ship channel	41. 3
	San Diego River and Mission Bay	12. 2
Oregon	Columbia-Lower Willamette River, 40-foot channel.	23. 3
	Chetco River, north jetty extension	1. 4
	Port Orford	1. 1
	Siuslaw River and Bar	0. 8
	Tillamook Bay and Bar	9. 7
	Yaquina Bay and Bar	11. 0
Great Lakes		(176. 8)
Illinois	Calumet Harbor and River, 1962 mod	10. 6
Indiana	Indiana Harbor	0. 1
Michigan	Great Lakes connecting channels	127. 5
	Point Lookout Harbor	1. 6
Ohio	Cleveland Harbor, 1958 act	13. 2
	Lorain Harbor, 1960 and 1965 acts	17. 3
Wisconsin	Green Bay Harbor	5. 5
	Kenosha Harbor	0. 9
	Milwaukee Outer Harbor	0. 1
Hawaii	Honokahau Harbor	0. 8
Alaska	Anchorage Harbor	5. 7
Total cost (56 projects).		$872. 9

[1] Includes the Great Lakes. All projects are considered by the Corps of Engineers to fall within their definition of coastal works.

[2] Listed projects are all in progress. Planned projects which are not yet underway have been excluded.

Source: Corps of Engineers—U.S. Army Civil Works.

Table H–3—U.S. Oil and Gas Drilling Activity and Production: Total and Offshore 1958–66

	Wells completed				Production [2]		Offshore production as percent of total United States	
	Oil	Gas [1]	Dry	Total	Oil [5] (million barrels)	Gas [3] (billion cubic feet)	Oil	Gas [3]
TOTAL								
1958	24, 137	4, 779	18, 822	47, 758	2, 449	11, 030	------	------
1959	25, 800	5, 029	19, 265	50, 094	2, 548	12, 046	------	------
1960	21, 186	5, 258	17, 574	44, 018	2, 575	12, 771	------	------
1961	21, 101	5, 664	17, 106	43, 871	2, 622	13, 254	------	------
1962	21, 249	5, 848	16, 682	43, 779	2, 676	13, 876	------	------
1963	20, 288	4, 751	16, 347	41, 386	2, 753	14, 847	------	------
1964	20, 620	4, 855	17, 488	42, 963	2, 805	15, 401	------	------
1965	18, 065	4, 724	17, 807	40, 374	2, 848	16, 039	------	------
1966	16, 780	4, 377	15, 227	37, 881	3, 043	17, 491	------	------
OFFSHORE [4, 6]								
1958	292	62	99	453	67	128	2. 7	1. 2
1959	281	88	117	486	93	207	3. 6	1. 7
1960	340	97	126	564	122	273	4. 7	2. 1
1961	295	114	133	542	136	318	5. 1	2. 4
1962	322	80	232	634	145	452	5. 4	3. 3
1963	312	71	307	690	168	564	6. 1	3. 8
1964	393	90	364	847	204	872	7. 3	5. 7
1965	486	65	424	975	228	1, 048	8. 0	6. 5
1966	584	166	489	1, 239	279	1, 581	9. 2	9. 0
1966 offshore as percent of total	3. 5	3. 8	3. 2	3. 3	9. 2	9. 0	------	------

[1] Includes field condensate.

[2] Marketed production.

[3] Offshore gas production volume and percent are for Louisiana only prior to 1964.

[4] Includes slant drilling from shore or piers as well as from offshore platforms.

[5] Total offshore oil production figures involve only Louisiana and California prior to 1966. During 1966, Alaska produced 2.6 million barrels. Texas figures are not included but production totaled only 3.4 million barrels from January 1960 to November 1967. Oregon and Washington have not been sites of commercial discoveries through 1966.

[6] Well completion figures before 1965 are for Louisiana only. The 1965 figure also includes Alaska and California and the 1966 entry also includes California, Alaska, and Texas.

Source: Bureau of Mines; U.S. Geological Survey; Alaska Department of Natural Resources; California Department of Conservation; Louisiana Department of Conservation; Railroad Commission of Texas; Battelle Memorial Institute; Oil and Gas Journal; Petroleum Production, Drilling and Leasing on the Outer Continental Shelf, U.S. Department of the Interior, 1966.

Table H–4—Estimated Value of Offshore Production of Crude Oil and Gas From Submerged Lands Off California and Louisiana, 1960–66

(Millions of dollars)

Year	California	Louisiana	Combined
Crude oil and field condensate:			
1960	78. 0	279. 5	357. 5
1961	82. 5	325. 1	407. 6
1962	85. 0	400. 1	485. 1
1963	89. 0	466. 7	555. 7
1964	90. 0	526. 5	616. 5
1965	101. 6	592. 0	693. 6
1966	125. 3	718. 4	843. 7
Total	651. 4	3, 308. 3	3, 959. 7
Natural gas and casinghead gas:			
1960	nil	69. 8	69. 8
1961	(1)	85. 7	85. 7
1962	1. 2	114. 3	115. 5
1963	5. 2	139. 9	145. 1
1964	12. 6	159. 0	171. 6
1965	13. 4	192. 2	205. 6
1966	14. 5	276. 2	290. 7
Total	[2] 46. 9	1, 037. 1	[2] 1, 084. 0
Combined value:			
1960	78. 0	349. 3	427. 3
1961	82. 5	410. 8	493. 3
1962	86. 2	514. 4	600. 6
1963	94. 2	606. 6	700. 8
1964	102. 6	685. 5	788. 1
1965	115. 0	784. 2	899. 2
1966	139. 8	994. 6	1, 134. 4
Total	[2] 698. 3	4, 345. 4	[2] 5, 043. 7

[1] Data not available.

[2] Total underestimated by value of 1961 California gas production.

Source: Battelle Memorial Institute; Bureau of Mines; State of Louisiana; U.S. Geological Survey; Bay Department of Conservation (Calif.); Mid-Continent Oil and Gas Association.

Table H–5—Industrial Expenditures on Offshore Oil and Gas Leases, by States and Recipient Governments, 1954–66 Inclusive

(Millions of dollars)

Year	California		Louisiana		Texas		Total	
	State	Federal	State	Federal	State	Federal	State [4]	Federal [2]
1954	0	0	42.4	117.6	(1)	23.6	42.4	141.2
1955	15.1	0	51.6	100.9	(1)	8.8	66.7	109.7
1956	10.1	0	23.6	4.0	(1)	0	33.8	4.0
1957	19.0	0	15.6	8.0	(1)	0	34.6	8.0
1958	65.8	0	10.5	15.0	(1)	0	76.3	15.0
1959	8.8	0	60.6	108.4	(1)	0	69.4	110.5
1960	8.2	0	14.2	[3] 278.3	(1)	36.4	30.7	[3] 314.7
1961	22.9	0	23.6	[3] 50.0	(1)	0	54.8	[3] 50.0
1962	38.1	0	25.4	[3] 569.8	(1)	.7	71.8	[3] 570.5
1963	23.5	13.7	17.2	[3] 70.2	(1)	.4	49.0	[3] 84.3
1964	75.9	.9	31.1	[3] 151.9	(1)	.4	115.3	[3] 190.5
1965	44.7	.7	30.2	15.1	(1)	.5	83.2	53.4
1966	43.3	.6	67.5	211.0	(1)	35.0	119.1	248.3
13-year totals	375.4	15.9	413.5	1,700.2	(1)	105.8	847.1	1,900.1

[1] Information on bonuses, rentals, and royalties paid to the State of Texas on offshore leases out to the 3-league line is not available. Annual amounts are believed relatively small.

[2] "Total Federal" includes other payments to the Federal Government: $2,100,000 from lands off Florida in 1959; $29,045,074 from lands off Oregon and $8,231,188 off Washington in 1965; and $1,276,302 off Oregon and $466,260 off Washington in 1966.

[3] Payments to Federal Government include amounts paid during 1960–64 inclusive for, bonuses, rentals, and royalties from zones 2 and 3, totaling $771,200,000, which is held in escrow awaiting final decision over these zones.

[4] Includes $8,300,000 to the State of Alaska, an average value over the period 1960–66, imputed to each year.

Source: Environmental Science Services Administration; Coast and Geodetic Survey; U.S. Department of Commerce; Battelle Memorial Institute; Bureau of Land Management; Department of the Interior; Louisiana Mineral Board; Alaska Department of Natural Resources; California State Lands Division; and supplementary sources.

Table H-6—Rents, Royalties, and Bonuses on Outer Continental Shelf Lands [1] for 1967

(Millions of dollars)

Location	Rents	Bonuses	Royalties	Total
Louisiana [2]	4.77	568.38	38.49	611.64
Texas	0.42	None	2.61	3.03
California	0.04	21.19	None	21.23
Oregon	1.03	None	None	1.03
Washington	0.36	None	None	0.36
Totals	6.62	589.57	41.10	637.29

[1] Federal lands; figures represent money received by the Federal Government.

[2] Figures do not include amounts placed in escrow which were earned on disputed land still under litigation. Louisiana figures however include a transfer to the Federal General Fund of monies previously tied up in escrow ($5,496,136 in bonuses and $527,328 in rentals), the disposition of which was resolved in 1967.

Table H-7—Petroleum Potential of Continental Shelves of the World [1]

(Areas in thousands of square miles)

Region	Shelf Area [2]	Excellent potential [3]			Fair potential [4]		
		Area	Percent of total Shelf of region	Percent of world excellent Shelf area	Area	Percent of total Shelf of region	Percent of World fair Shelf area
Total World	10,763	188	1.8	100.0	1,657	15.3	100.0
North America	2,140	40	1.9	21.3	315	14.7	19.0
South America	910	20	2.2	10.6	150	16.5	9.1
Middle East, Asia	200	40	20.2	21.3	65	32.5	3.9
East Indies Islands (Incl. Philippines)	1,350	35	2.6	18.6	305	22.6	18.4
Iron Curtain Countries	2,718	35	1.3	18.6	385	14.2	23.2
Other Areas [5]	3,445	18	5.2	9.6	437	12.7	26.4

[1] Adapted from "Offshore Operations Around the World"; Weeks, Lewis G., *Offshore*, June 20, 1967, Vol. 27, No. 7.

[2] Areas to depth of 1000 feet of water.

[3] "Excellent Potential" rating is given to areas containing or in continuity with excellent producing areas and with like geology.

[4] "Fair Potential" rating is given an area containing or in continuity with a fair producing area, or when geology is similarly favorable for commercial production.

[5] Includes Europe, Africa, Far East, Oceania, and Antarctica.

Table H–8—Employment in Selected Ocean-Related Industries in Coastal States and Those Bordering the Great Lakes, 1966

(Thousands of employees)

	Total employed in selected industries [2]	Fisheries	Manufacturing		Ship and boat building and repairs	Water transportation [1]	Wholesale trade: Fish and seafoods
			Canned or cured seafood	Fresh or frozen packaged fish			
All coastal States	334. 1	16. 1	22. 0	18. 6	104. 7	167. 2	14. 6
Alabama	3. 6	0. 4	NA	0. 2	[3] 0. 1	2. 3	0. 5
Alaska	1. 6	0. 1	0. 9	0. 2	NA	0. 4	NA
California	43. 0	2. 0	4. 2	0. 8	16. 3	18. 4	1. 3
Connecticut	1. 0	0. 1	NA	NA	[3] 0. 3	0. 6	0. 1
Delaware	0. 5	NA	NA	NA	NA	0. 5	NA
Florida	20. 9	1. 7	0. 3	1. 7	9. 7	6. 0	1. 5
Georgia	4. 7	0. 3	NA	1. 8	1. 5	0. 8	0. 2
Hawaii	2. 3	NA	NA	NA	NA	2. 2	0. 1
Illinois	4. 3	0. 1	0. 3	NA	0. 9	2. 5	0. 5
Indiana	0. 7	NA	NA	NA	NA	0. 7	NA
Louisiana	37. 0	1. 2	0. 9	0. 8	[4] 10. 9	22. 5	0. 8
Maine	6. 9	0. 3	1. 3	0. 5	3. 8	0. 5	0. 5
Maryland	20. 8	0. 1	NA	1. 9	10. 4	7. 6	0. 8
Massachusetts	15. 1	3. 9	0. 4	3. 5	2. 0	3. 7	1. 5
Michigan	4. 6	0. 2	NA	NA	3. 1	1. 0	0. 3
Minnesota	2. 3	0. 1	NA	NA	1. 9	0. 4	NA
Mississippi	2. 6	0. 2	0. 2	NA	[3] 0. 2	1. 8	0. 1
New Jersey	21. 3	0. 4	0. 8	0. 3	8. 8	10. 6	0. 4
New York	45. 5	0. 3	0. 6	0. 3	5. 1	37. 4	1. 6
North Carolina	3. 9	0. 5	0. 2	0. 2	1. 1	1. 1	0. 8
Ohio	7. 6	0. 1	NA	NA	2. 7	4. 6	0. 2
Oregon	8. 9	0. 2	0. 7	0. 5	3. 3	4. 1	0. 3
Rhode Island	1. 7	0. 1	NA	NA	0. 9	0. 4	0. 2
South Carolina	3. 2	0. 1	0. 2	0. 2	1. 0	1. 6	0. 1
Texas	35. 6	1. 6	NA	2. 2	8. 8	22. 0	0. 9
Virginia	9. 8	1. 2	0. 5	2. 3	NA	4. 8	1. 1
Washington	20. 6	0. 8	1. 4	1. 1	8. 7	8. 1	0. 6
Wisconsin	3. 8	0. 1	NA	NA	3. 1	0. 4	0. 2

[1] Excludes employment on oceanborne vessels.

[2] Totals less than actual figures since some items were not reported (NA).

[3] Boatbuilding and repairing only.

[4] Shipbuilding and repairing only.

NA = Figures not available. In most instances, figures were withheld to avoid disclosure of individual reporting units.

NOTES

Employment as shown here is the reported wage and salary employees of private nonfarm employers and certain nonprofit organizations covered under the Federal Insurance Contributions Act. The data are as of the pay period including Mar. 12, 1966.

Entries for "all coastal States" do not necessarily equal total for the United States, since some ocean-related industry is conducted in inland States.

Columns may not add because of rounding of figures.

Source: Country Business Patterns, 1966, U.S. Department of Commerce, Bureau of the Census.

Table H-9—Reporting Units, Selected Ocean-Related Industries in Coastal States and Those Bordering the Great Lakes, 1966

	Selected industries, grand total [2]	Selected industries—units with 50 and more employees	Fisheries	Manufacturing		Ship and boat building and repairs	Water transportation [1]	Wholesale trade, fish and seafood
				Canned or cured seafoods	Fresh or frozen packaged fish			
All coastal States	11, 826	1, 005	2, 902	303	401	1, 661	4, 131	1, 423
Alabama	181	22	36	2	6	23	68	24
Alaska	123	9	34	48	12	NA	20	NA
California	1, 065	100	272	23	26	224	326	94
Connecticut	141	4	27	NA	NA	34	57	19
Delaware	37	3	NA	NA	NA	NA	34	NA
Florida	1, 259	82	428	10	35	209	334	161
Georgia	214	18	68	3	13	21	42	49
Hawaii	107	11	53	6	NA	5	21	11
Illinois	243	22	11	4	5	14	143	44
Indiana	70	10	NA	NA	NA	29	31	NA
Louisiana	1, 533	110	310	23	24	100	877	89
Maine	308	21	58	30	12	58	35	94
Maryland	417	54	23	9	50	70	148	63
Massachusetts	767	41	342	10	50	82	112	130
Michigan	259	17	47	NA	NA	57	103	35
Minnesota	90	10	13	NA	NA	30	37	NA
Mississippi	160	15	20	7	NA	25	78	15
New Jersey	482	52	91	10	8	97	177	47
New York	1, 037	100	62	22	18	139	493	203
North Carolina	256	14	89	6	13	36	40	58
Ohio	242	26	21	NA	NA	31	141	23
Oregon	235	25	48	12	12	31	93	14
Rhode Island	130	7	48	NA	NA	23	31	21
South Carolina	120	14	29	6	6	15	34	16
Texas	1, 046	101	402	NA	20	114	334	75
Virginia	548	52	180	9	70	58	106	73
Washington	615	55	159	63	21	97	175	45
Wisconsin	141	10	31	NA	NA	39	41	20

[1] Does not include oceangoing vessels as employing organizations.

[2] Totals less than actual figures since some items have not been reported (NA).
NA=Figures not available.

NOTES

"All coastal States" entries do not necessarily equal total for United States, since some ocean related industry is conducted in inland States.

"Reporting units" are establishments reporting covered employment under the Federal Insurance Contributions Act during first quarter of 1966.

Columns may not add because of rounding of figures.

Source: County Business Patterns, 1966, U.S. Department of Commerce, Bureau of the Census.

Table H–10—Taxable Payrolls Reported to Social Security Administration by Establishments in Selected Ocean-Related Industries in Coastal States and Those Bordering the Great Lakes, First Quarter, 1966

(Millions of dollars)

	Total payroll in selected industries [2]	Fisheries	Manufacturing		Shipbuilding and boatbuilding and repairs	Water transportation [1]	Wholesale trade, fish and seafood
			Canned or cured seafood	Fresh or frozen packaged fish			
All coastal States	465.5	17.9	12.3	13.9	167.0	240.2	14.2
Alabama	3.3	0.2	NA	0.2	[3] 0.1	2.5	0.2
Alaska	2.1	0.1	1.2	0.4	NA	0.5	NA
California	76.4	3.5	4.9	0.8	29.2	36.4	1.6
Connecticut	1.5	0.1	NA	NA	[3] 0.4	0.8	0.1
Delaware	0.5	NA	NA	NA	NA	0.5	NA
Florida	23.3	1.6	0.2	1.2	13.4	5.5	1.4
Georgia	3.9	0.1	NA	1.2	1.8	0.5	0.2
Hawaii	4.1	NA	NA	NA	NA	4.0	0.1
Illinois	6.9	0.1	0.3	NA	1.4	4.4	0.7
Indiana	1.3	NA	NA	NA	NA	1.3	NA
Lousiana	48.9	1.0	0.4	0.3	[4] 17.9	28.7	0.4
Maine	7.6	0.5	0.7	0.4	5.0	6.2	0.4
Maryland	25.2	0.1	NA	0.8	16.0	7.8	0.5
Massachusetts	18.0	5.0	0.4	4.0	2.9	3.8	1.9
Michigan	6.8	0.2	NA	NA	4.4	1.8	0.4
Minnesota	2.6	0.03	NA	NA	1.9	0.7	NA
Mississippi	2.2	0.2	0.1	NA	[3] 0.2	1.6	0.1
New Jersey	31.8	0.6	0.9	0.2	15.4	14.3	0.4
New York	79.6	0.3	1.0	0.4	8.5	66.7	2.6
North Carolina	3.2	0.3	0.04	0.1	1.2	1.2	0.4
Ohio	11.6	0.1	NA	NA	4.1	7.1	0.3
Oregon	15.9	0.2	0.5	0.3	6.6	8.1	0.2
Rhode Island	2.5	0.3	NA	NA	1.1	0.9	0.2
South Carolina	3.1	0.1	0.1	0.04	1.2	1.6	0.1
Texas	36.9	1.2	NA	1.6	13.8	19.5	0.7
Virginia	7.0	0.1	0.1	1.0	NA	4.5	0.6
Washington	34.6	1.0	1.3	1.1	16.0	14.8	0.6
Wisconsin	5.0	0.1	NA	NA	4.2	0.6	0.1

[1] Excludes payments to employees aboard oceanborne vessels.
[2] Totals less than actual figures since some items were not reported (NA).
[3] Boatbuilding and repairing only.
[4] Shipbuilding and repairing only.
NA = Figures not available.

NOTES

"All coastal States" entries do not necessarily equal total for the United States since some ocean-related industry is conducted in inland States.

Taxable payrolls is the amount of taxable wages paid for covered (under F.I.C.A.) employment during January–March 1966. This is generally the total wages paid for the first quarter, except for employees paid at rates in excess of $19,200 per year.

Columns may not add because of rounding of figures.

Source: Country Business Patterns, 1966, U.S. Department of Commerce, Bureau of the Census.

Table H–11—World Catch [1] of Fish, Shellfish, Etc. by Leading Countries, 1954–66

(In billions of pounds)

Country ranking by 1966 catch figures	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966 [2]
Peru	0.4	0.5	0.7	1.1	2.2	4.8	7.9	11.7	15.3	15.2	20.2	16.5	19.4
Japan	10.0	10.8	10.5	11.9	12.1	13.0	13.7	14.8	15.1	14.8	14.0	15.2	15.6
China	5.1	5.6	5.8	6.9	8.9	11.0	12.8	NA	NA	NA	NA	NA	NA
U.S.S.R	5.0	5.5	5.8	5.6	5.8	6.1	6.7	7.2	8.0	8.3	9.9	11.0	11.8
Norway	4.5	4.0	4.8	3.9	3.2	3.5	3.4	3.4	2.9	3.1	3.5	5.0	6.3
United States	6.1	6.1	6.5	6.0	5.9	6.4	6.2	6.5	6.6	6.1	5.8	6.0	5.5
World	60.5	63.5	67.1	69.3	72.4	80.1	87.1	94.6	102.0	105.0	114.0	115.5	125.0

[1] Total commercial catches, including fresh water fish, on a live weight basis. Weights of shells of univalve and bivalve mollusks are included.

[2] Preliminary.

NA=Not available.

NOTE.—U.S. totals in table H–15 are smaller than those for comparable years in the above table since the weights of mollusk shells are not included.

Source: Yearbook of Fishery Statistics, Food and Agriculture Organization of the United Nations.

Table H–12—Disposition of World Fish Catch, 1938, 1948, 1953, and 1958–65

(Millions of metric tons on a live weight basis)

	Total world catch	For human consumption					For other purposes		
		Total	Marketing (fresh)	Freezing	Curing	Canning	Total	Reduction [1]	Miscellaneous purposes
1938	21.0	18.3	11.0		5.7	1.5	2.7	1.7	1.0
1948	19.6	17.1	9.7	1.0	5.0	1.4	2.5	1.5	1.0
1953	25.7	22.0	11.8	1.4	6.5	2.3	3.9	2.9	1.0
1958	32.8	27.5	14.5	2.7	7.3	3.0	5.3	4.3	1.0
1959	36.4	29.1	15.4	3.0	7.4	3.3	7.3	6.3	1.0
1960	39.5	30.9	16.3	3.4	7.5	3.7	8.6	7.6	1.0
1961	43.0	32.3	16.5	4.0	7.8	4.0	10.7	9.7	1.0
1962	46.4	33.4	16.9	4.3	8.1	4.1	13.0	12.0	1.0
1963	47.6	34.6	17.3	4.7	8.5	4.1	13.0	12.0	1.0
1964	52.0	35.5	17.6	5.1	8.4	4.4	16.5	15.5	1.0
1965	52.4	36.1	17.5	5.7	8.1	4.8	16.3	15.3	1.0

[1] Only whole fish destined for the manufacture of oils and meals is included. Raw material for reduction derived from fish primarily destined for marketing fresh, freezing, curing, canning, and miscellaneous purposes is excluded; such waste quantities are included under the other disposition channels.

Source: Yearbook of Fishery Statistics, 1965, Food and Agriculture Organization of the United Nations.

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Table H–13—U.S. Catch of Fish and Shellfish, 1940, 1945, 1950, 1955, 1960–66

(Round weight basis)

Year	Catch for human food	Catch for industrial products [1]	Total		Average price per pound
	Million pounds	*Million pounds*	*Million pounds*	*Million dollars*	*Cents*
1940	2, 674	1, 385	4, 059	99	2. 44
1945	3, 167	1, 431	4, 598	270	5. 87
1950	[2] 3, 307	1, 594	4, 901	347	7. 09
1955	2, 579	2, 230	4, 809	339	7. 05
1960	2, 498	2, 444	4, 942	354	7. 15
1961	2, 490	2, 697	5, 187	362	6. 98
1962	2, 540	[2] 2, 814	[2] 5, 354	396	7. 40
1963	2, 556	2, 291	4, 847	377	7. 78
1964	2, 497	2, 044	4, 541	389	8. 57
1965	2, 587	2, 190	4, 777	446	9. 34
1966 [3]	2, 568	1, 773	4, 341	[2] 454	[2] 10. 47

[1] Processed into meal, oil, fish solubles, homogenized condensed fish, shell products, and used as bait and animal food.

[2] Record.

[3] Preliminary.

NOTES.—Does not include data on the Hawaiian catch prior to 1946.

Totals are smaller than comparable year U.S. totals in table H–13 since weights of univalve and bivalve mollusks are not included.

Source: Fisheries of the U.S., 1966, Bureau of Commercial Fisheries.

Table H–14—U.S. Imports and Exports of Fishery Products, 1950–66

(Thousands of dollars)

Year	Edible fish		Nonedible fish		Totals		
	Imports	Exports	Imports	Exports	Imports	Exports	Excess imports over exports
1950	158, 414	18, 856	39, 882	8, 618	198, 296	27, 474	170, 822
1951	158, 363	27, 072	54, 094	8, 659	212, 457	35, 731	176, 726
1952	183, 121	15, 511	57, 308	6, 436	240, 429	21, 947	218, 482
1953	195, 869	17, 084	49, 611	10, 794	245, 480	27, 878	217, 602
1954	203, 722	16, 238	48, 687	15, 289	252, 409	31, 527	220, 882
1955	208, 973	24, 923	49, 896	15, 054	258, 869	39, 977	218, 892
1956	234, 699	22, 939	48, 031	16, 564	282, 730	39, 503	243, 227
1957	252, 788	20, 549	46, 487	15, 403	299, 275	35, 952	263, 323
1958	283, 822	19, 440	46, 959	11, 564	330, 781	31, 004	299, 777
1959	314, 650	26, 747	55, 467	17, 495	370, 117	44, 242	325, 875
1960	310, 596	25, 622	52, 685	18, 543	363, 281	44, 165	319, 116
1961	339, 318	19, 594	61, 301	15, 116	400, 619	34, 710	365, 909
1962	405, 832	22, 470	83, 975	13, 258	489, 807	35, 728	454, 079
1963	399, 928	30, 376	100, 784	26, 229	500, 712	56, 605	444, 107
1964	433, 674	42, 878	130, 569	21, 326	564, 243	64, 204	500, 039
1965	479, 412	49, 308	121, 492	20, 175	600, 904	69, 483	531, 421
1966	[1] 568, 216	[1] 62, 882	[1] 152, 231	21, 931	[1] 720, 447	[1] 84, 813	[1] 635, 634

[1] Record.

Source: Fishery Statistics of the U.S., 1966, Bureau of Commercial Fisheries.

Table H-15—U.S. Fishery Employment, Fishing Craft, and Establishments, Various Years, 1930–65

Item	1930	1940	1950	1960	1965
Persons employed, direct:	*Number*	*Number*	*Number*	*Number*	*Number*
Fishermen	119, 716	124, 795	161, 463	130, 431	128, 565
Shoreworkers [2]	78, 996	90, 215	102, 015	93, 625	86, 865
Total	198, 712	215, 010	263, 478	224, 056	215, 430
Craft utilized, fishing:					
Vessels (5 net tons and over)	4, 374	5, 562	11, 496	12, 018	12, 311
Motor boats	35, 437	31, 055	46, 067	56, 889	63, 828
Other boats	37, 961	35, 193	34, 747	8, 150	3, 393
Total	77, 772	71, 810	92, 310	77, 057	79, 532
Vessels, documented for fishing:					
First documentation	(1)	320	812	408	612
Redocumentation	(1)	(1)	29	24	51
Total	(1)	(1)	841	432	663
Fishery shore establishments: [2]					
Pacific Coast States	569	579	700	515	557
Atlantic Coast and Gulf States	2, 024	2, 038	2, 699	2, 898	2, 931
Great Lakes and Mississippi River States	402	438	484	772	677
Hawaii	(1)	(1)	(1)	22	24
Total	2, 995	3, 055	3, 883	4, 207	4, 189

[1] Data not available.

[2] Wholesale and Manufacturing Industry.

Source: Fishery Statistics of the U.S., 1965, Bureau of Commercial Fisheries.

Table H–16—U.S. Fishing Fleet, 1965, By Period of Construction

Period in which constructed	New England	Middle Atlantic	Chesapeake [1]	South Atlantic	Gulf	Pacific	Great Lakes [2]	Hawaii	Total exclusive of duplication
Before 1900	3	14	21	5	7	4	0	0	49
1900–1904	5	15	23	3	12	8	0	0	65
1905–09	2	20	20	0	17	34	1	0	94
1910–14	6	19	35	7	10	140	4	0	218
1915–19	14	18	28	5	18	287	1	0	359
1920–24	23	21	48	22	47	189	6	0	350
1925–29	68	33	57	33	106	466	19	10	782
1930–34	53	31	56	57	66	177	23	4	454
1935–39	64	40	110	72	218	352	69	6	905
1940–44	140	99	144	126	270	672	47	4	1, 418
1945–49	160	109	268	265	622	1, 058	139	26	2, 575
1950–54	60	67	181	144	774	612	37	4	1, 816
1955–59	40	56	263	238	778	367	28	1	1, 657
1960–64	50	33	133	109	554	394	2	2	1, 213
1965	11	1	8	18	160	52	1	------	247
Unknown	4	3	18	18	24	43	------	------	109
Total	703	579	1, 413	1, 122	3, 683	4, 855	377	57	12, 311

[1] Includes sailing vessels.

[2] Includes 4 vessels operated in Lake Winnebago, 2 of which were also operated in the Great Lakes.

Source: Fishery Statistics of the United States, 1965, Bureau of Commercial Fisheries.

Table H–17—Disposition of U.S. Fish Catch, 1958 and 1961–65

(Thousand of metric tons on a live weight basis)

	1958	1961	1962	1963	1964	1965
Total	2, 703. 4	2, 932. 1	2, 972. 9	2, 776. 9	2, 647. 2	2, 701. 2
For human consumption	1, 844. 3	1, 819. 4	1, 820. 3	1, 852. 9	1, 835. 7	1, 848. 9
Marketing (fresh)	822. 3	864. 1	843. 3	852. 3	887. 2	922. 6
Freezing	302. 1	296. 7	313. 4	317. 9	298. 9	340. 2
Curing	38. 6	36. 7	36. 3	35. 4	32. 2	34. 5
Canning	681. 3	621. 9	627. 3	647. 3	617. 4	551. 6
For other purposes	859. 1	1, 112. 7	1, 152. 6	924. 0	811. 5	852. 3
Reduction (meal, oil, etc.)	852. 8	1, 100. 9	1, 143. 1	912. 2	805. 6	843. 7
Miscellaneous purposes	6. 3	11. 8	9. 5	11. 8	5. 9	8. 6
Offal for reduction	(308. 4)	(248. 1)	(217. 7)	(213. 6)	(184. 6)	(206. 4)

Source: Yearbook of Fishery Statistics, 1965, Food and Agriculture Organization of the United Nations.

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